

University of Dundee

## DOCTOR OF PHILOSOPHY

### Can music and animation affect flow and attainment in online learning?

Grice, Sue

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Sue Grice

2010

University of Dundee

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# **Can Music and Animation Affect Flow and Attainment in Online Learning?**

**Sue Grice**

**PhD in Applied Computing**

**University of Dundee**

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## **DECLARATION BY THE CANDIDATE**

**I declare that I am the author of this thesis; that unless otherwise stated, all references cited have been consulted by me; that the work of which the thesis is a record has been done by me, and that it has not been previously accepted for a higher degree.**

**Sue Grice  
September 2010**

## **DECLARATION BY THE SUPERVISOR**

**I declare that Sue Grice has satisfied all the terms and conditions of the regulations made under Ordinances 12 and 39; and has completed the required 9 terms of research to qualify in submitting this thesis in application for the degree of Doctor of Philosophy.**

**Dr Janet Hughes  
September 2010**

## **ABSTRACT**

E-learning has found its way into various areas of our lives and, as technology has developed, the ways in which e-learning has been delivered have become more varied. Researchers and e-learning developers can become captivated by new technologies and the facilities that these technologies can offer. However, increased availability does not necessarily mean better facilities or results. In the early days of e-learning, materials were generally just text-based and the use of multimedia elements such as audio was very limited, whilst current materials generally incorporate much multimedia and often result in materials that are ‘all singing all dancing’. However, there has been little research into the benefits of such ‘entertaining’ learning materials over the older-style text-based learning materials. The research described in this thesis explored the use of music and animation within an e-learning environment and the effects it might have upon a learner - in particular how music and animation might affect a learner’s emotional state and learning attainment. The model of flow was used to determine the emotional state of the learner. Flow can be used to describe focused motivation, when a person is fully immersed in a task. Several experiments were designed and carried out to determine the effects of including music and animation in an e-learning application. It was found that while the learning attainment was unaffected by the inclusion of the music and animation, learners’ flow experiences were negatively affected. These findings highlighted the importance of the design phase of learning material and it should also be considered that adding more multimedia elements does not necessarily lead to improved learning or enhanced learner satisfaction.

**ASSOCIATED PUBLICATIONS**

Grice, S., Hughes, J. (2009). Can music and animation improve the flow and attainment in online learning?. *Journal of Educational Multimedia and Hypermedia*, 18(4), pp.385-403.

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Grice, S. (2006). The power of music. BA Science Festival, Norwich, England (Poster).



## **CHAPTER 1**

### **INTRODUCTION TO E-LEARNING**

In this rapidly growing world of e-learning, the technology available to designers of courses has changed much since the early days of text-based e-learning applications. Research has been working hard to keep up with the latest technology developments to identify the most appropriate uses of this technology so that it may be of benefit to students. If e-learning applications fail to deliver the quality of learning environment that students require, this can not only be frustrating for the students but also costly to the educational institutions who are delivering the courses. This research aims to identify if there are any benefits to students when animation or music are incorporated into an e-learning application. As an introduction, this chapter provides an overview of e-learning and considers the e-student – the needs of a student in an e-learning environment often differ from those of a student studying in a classroom environment. Then some of the different technologies that can be used to enhance the student's learning attainment and experience within an e-learning environment are described. Lastly the uses of multimedia and audio within computing and e-learning applications are considered. Further chapters provide more background into the uses of music, human emotions and emotional models in e-learning.

#### **1.1 What is an e-learning environment?**

In the following sections the various components of an e-learning environment will be considered.

**E-learning**

E-learning can be described as a learning process in which the content is delivered digitally and may also be supported digitally, for example with interactions between a tutor and a student via email. E-learning is a wide-reaching term that not only describes learning materials delivered via the World Wide Web, but also via other digital means such as on a stand-alone machine with a CD-ROM or DVD, a mobile phone, or a personal digital assistant (PDA). Other terms are often used to describe specific areas of e-learning, such as Web-based learning, Web-based training, and Internet-based learning. These refer to e-learning that is being delivered specifically via the World Wide Web (Hill, Wiley, Nelson & Han, 2003; McKimm, Jollie & Cantillon, 2003), whereas terms such as ‘computer-assisted learning’ and ‘computer-based learning’ are more often used to describe stand-alone learning packages. From here onwards the term e-learning will be used to describe the delivery of learning materials by any digital means.

E-learning may take place in a synchronous manner, i.e., the learner is engaged in the learning in real time, for instance in a web conference or a chat facility with students or a tutor. Alternatively the learning may take place asynchronously, that is to say the learner may be engaged in the learning process independently from others at a time to suit them. Blended learning describes the combination of traditional classroom-based learning and e-learning. The introduction of Virtual Learning Environments (VLEs) into educational establishments in the UK has greatly increased over the last few years. The Universities and Colleges Information Systems Association have indicated that the use of VLEs in higher education establishments increased from 81% in 2001 to 95% in 2005 within the institutions they surveyed (Browne, Jenkins & Walker, 2006).

These VLEs not only offer digital delivery of materials, but also provide many other facilities such as email, discussion boards, collaboration tools, online assessments, and virtual classrooms.

E-learning is not restricted to educational establishments. Examples of e-learning can be seen in all walks of life, from buying a train ticket from a ticket vending machine (where instructions are presented on screen explaining how to purchase the ticket), to learning a foreign language from a web site or CD-ROM, or listening to or watching a lecture via a podcast.

Although providing simple instructions on a screen may not necessarily be in the same category as a university lecture in terms of the depth of learning taking place, for the purposes of this research any teaching materials or instructions provided via electronic means will be classed as e-learning.

Ease of accessibility to learning is one of many advantages e-learning has over traditional methods such as classroom-based learning. As society is moving towards being 'online' twenty four hours a day, seven days a week (24/7), there is a growing demand for learning to be available anytime, anywhere and to anyone (Jones & Jo, 2004). This is not practical in traditional classroom environments and so e-learning is becoming an increasingly important way to learn. Learning opportunities are increased for those people who are disabled or housebound who may not be able to access them through normal routes but who have access to appropriate digital tools (Hamburg, Hamburg, Gavota & Lazea, 2004). Cheong (2001) indicates that due to the power of information communication technology (ICT), inexpensive real-time global communications are now possible, allowing students and tutors geographical freedom. Keller & Cernerud (2002) and Cheong (2001) identified that communications between students could also be enhanced in online environments.

However, the biggest advantage identified by Keller & Cernerud (2002) to using a web-based platform (which included functions such as discussion forums, chat facilities, messages and lectures) was that access to information (documents, announcements and messages) was increased by up to 44% compared to non web-based methods of access such as face-to-face and email. Additionally, this information is available 24/7 and can also include digital libraries, learning repositories and vast quantities of information available via the Internet (Ruiz, Mintzer & Leipzig, 2006; Bonk, Wisher & Lee, 2004; Collins, Buhalis & Peters, 2003; Cheong, 2001). Geographical independence brings with it other benefits, such as reduced transport issues and commuting time (Collins, Buhalis & Peters, 2003; Cheong, 2001), reduced overhead costs for institutions (Ruiz et al. 2006; Collins et al. 2003), better integration of learning with work (Collins et al. 2003), and the potential for personal anonymity (Bonk et al. 2004).

Temporal independence can be another benefit that e-learning has over traditional classroom-based learning, as it allows for more personalised learning with students working at their own pace (Cheong, 2001). Materials can be delivered in a manner to suit the particular learning style of the student (Siadat & Taghiyareh, 2007; Wolf, 2002). It was also suggested by Bonk, Wisher and Lee (2004) that delayed collaborations, e.g., email and discussion boards, are more extensive and richer than real-time collaborations where communication is more immediate and personal.

From a commercial perspective, although e-learning courses can be profitable, their setup costs must not be underestimated (Collins et al. 2003; Harun, 2001; Strother, 2002). Various elements need to be considered for an e-learning course to be viable, such as the necessary infrastructure to provide and support the course (Collins et al. 2003), the provision of good quality learning materials delivered in a well structured and appropriate way, and sufficient support for social interaction (Harun, 2001). However, if some of these elements are lacking it can lead to students becoming

frustrated (Bonk et al. 2004; Harun, 2001); in particular the social interaction between students, tutors and peers seems to be of key importance in the success of a course (Collins et al. 2003; Keller & Cernerud, 2002; Harun, 2001). Grice, Whaley, Peiris & Hughes (2006) also suggested that it is not suitable to simply upload the lecture slides from a classroom based presentation. Although the content may be the same, if a lecturer is not present to expand the content of the slides, the slides often require additional information to enable them to become self-presenting.

Another crucial component of e-learning is the student, each bringing their own set of attributes such as their level of technical proficiency, motivation, self efficacy, self discipline, their particular learning style and strategy preferences.

### **The e-student**

A student's satisfaction and success with a course, be it traditional or e-learning, will depend upon various factors such as their level of self efficacy (their belief in their own capabilities) in the subject area, their technical abilities (in an e-learning environment particularly), and their level of motivation. While their motivation may be intrinsic (i.e., self motivated to complete a task just for the enjoyment or interest in the task itself) or extrinsic (i.e., motivated by external factors such as a financial reward for completing a task), both will play an important role in a student's level of satisfaction of a course. For example, a student who is experiencing technical difficulties is likely to develop a lack of motivation (Bonk et al. 2004) or, as Pintrich (1999) points out, students who have positive self-efficacy and task value beliefs are better able to manage their learning as they have highly self-regulated behaviour. Similarly others have found that students' self-efficacy has an impact upon their expectations and experiences of a course (Wang & Lin, 2007; Vuorela & Nummenmaa, 2004; Chou, 2001).

Since computing domains have traditionally been male dominated, this can lead to females having a lower self-efficacy and often experiencing higher levels of anxiety (Chou, 2001; Chua, Chen & Wong, 1999; Coffin & MacIntyre, 1999). Gender can have an impact upon the learner. All these attributes combine to form an individual learner with individual needs who has their own unique way of proceeding through the learning process.

During this process, students will have their own preferred learning styles and this will also play a crucial role in their learning. The term 'learning style' appeared around about 1970 (Robotham, 1999) and has been used to indicate the whole learning process and describes the way in which a learner approaches a particular task. The term 'cognitive style' is sometimes used in place of learning style; however, it is generally accepted that a cognitive style only describes a small part of a person's learning style (Robotham, 1999). Generally a person's learning style is considered to be temporally stable, in that it does not change much over time. However, a person's learning strategy may change as it involves a conscious choice by the learner as to how they will handle their behaviour in a particular learning situation (Pithers, 2002). It is understood that although a learning strategy can be adaptable, it is still influenced by the underlying and more permanent and persuasive learning style (Messick, 1984).

There have been many different ways of describing an individual's learning style, such as Witkin's field dependent (FD) or field independent (FI). These two categories are distinguished by the way people reference and interact with their surroundings; for example an FI person would prefer working alone whereas the FD person would prefer group work.

Many studies have shown how FD and FI people differ. Recent studies have examined the different ways people navigate in hypermedia depending upon their level of FD or FI. These studies have almost universally found that there is a fundamental difference in how people navigate hypermedia according to their FD and FI preferences. FD people cope better when being directed and using linear steps, often becoming disorientated when using 'free' navigation. In contrast FI people prefer free navigation and the autonomy it provides (Bromme & Stahl, 2005; Lee, Cheng, Rai & Depickere, 2005; Chen & Macredie, 2002).

Another example of mapping a learner's style which is commonly used is the Myers-Briggs Type Indicator (MBTI). The MBTI is not strictly speaking a learning style indicator as it falls more into the category of a personality model. However, perhaps because a learner's personality has an influence over their learning process, it is often used and referred to as an indicator of learning styles,

Many other learning style models have been proposed in an attempt to better categorise a learner's preferred approach to a learning task, such as Gardner's Multiple Intelligences and Kolb's learning styles (Alty, Sharrah & Beacham, 2006; Kelly, 2003; Miller, 2005). Coffield, Moseley, Hall & Ecclestone (2004) identified 71 learning styles and categorised them into 13 models. These styles are not designed to pigeonhole a person into a category, but instead are designed to provide an indication of a person's preferences. For example, with Gardner's Multiple Intelligences some of the categories are visual/spatial, verbal/linguistic, logical/mathematical, musical/rhythmic and bodily/kinaesthetic. While a person may have a stronger preference for visual/spatial than for verbal/linguistic, this does not mean that they cannot cope at all with materials

presented in a verbal/linguistic manner, but they are likely to cope better with materials presented in a visual manner.

Due to a student's learning style preferences, their perception of a course may depend upon the style in which the learning materials are delivered. In a classroom-based environment the teacher may provide the content via a variety of channels: by writing on a blackboard, providing handouts, talking about the content, or by carrying out a practical activity. This style of teaching suits for a range of learning styles such as visual, audio, read/write and kinaesthetic. The teacher may also help the students to manage their learning, encouraging and motivating them throughout the learning process (Campbell, Campbell & Dickinson, 1996; Brown, 1994). However, students studying in an e-learning environment require some different skills from those needed for classroom-based learning. In an e-learning environment students need to be more self-motivated and self-disciplined in order to manage their own learning. E-learners also need to be able to overcome any problems encountered in an independent manner (Song, Singleton, Hill & Koh, 2004; Diaz & Cartnal, 1999), as compared to classroom-based learners where a teacher may recognise that a student does not understand something and adapt the way it is structured, or explain it in a different way to help the student (Morrison, Sweeney & Heffernan, 2003).

As the popularity of e-learning is increasing, so are the number of tools available to teachers to develop online materials such as "Easy-E-Publishing", a tool designed for people with little computing knowledge to help them prepare and publish content for e-learning purposes (Mirski & Bernsteiner, 2004). Various guidelines have been created for the development of e-learning courses (Grice et al, 2006; Savenye, Olin & Niemczyk, 2001). There is also a growing body of research into the different ways that



individualised, adaptive and motivating e-learning environments can be provided, as described in the following sections.

### **Interaction layers**

Before taking a closer look at individualised and adaptive e-learning environments it is important to understand the concept of interaction between the student and the e-learning environment. There are several layers within a learning environment that the student may interact with, such as the hardware, the web browser, the content, other students or the teacher. All of these different types of interactions may be affected by the design of the computer system. For example a student may be disinclined to initiate an interaction with a teacher's emails if the system is difficult to navigate and the text is too small and difficult to read. Swan's (2004) review of research identified three main layers: the interaction with the content, the interaction with the instructor and the interaction with other peers. These layers may be found in both classroom and e-learning environments. However, another level of interaction can occur that is normally only found within e-learning environments: the learner's interaction with the platform, the browser and the design of the page. This layer of interaction is what Thurmond & Wambach (2004) refer to as the 'learner-interface' type of interaction. When the learner is interacting with the content, they often have to interact with the browser and the design of the content page before they get to the content itself. This can often be a cause of anxiety for users who are unfamiliar with such an environment (Sun, Tsai, Finger, Chen & Yeh, 2008). Swan also indicated that the interaction with these different layers can also affect the meanings the learners understand from the content, although no examples were given (Swan, 2004). The student's interaction with the different layers is of paramount importance as it can cause the success or failure of a learning experience.

At a higher level of abstraction within the content layer, the manner in which a student is introduced to an e-learning application can affect how the student then proceeds to use the application. This has been shown in a variety of research, including that of Armentano, Godoy & Amandi, (2006) and Bromme & Stahl (2005). Bromme & Stahl's (2005) research showed how using different metaphors can affect a student's perception of the environment. They introduced users to hypertext in two different ways, by describing it as a 'book' and as a 'space'. Their results showed that users were better able to understand the complexities of the hypertext structure when using the 'space' metaphor, although there was no significant difference in the knowledge test results at the end. This led them to conclude that the learning process was not deeper when using the 'space' rather than the 'book' metaphor, despite the superior understanding of the environment when using the 'space' metaphor.

The question arises of what effect this improved understanding has upon the student, if any. Maybe one should consider the possibility that users are more satisfied with the learning process when using an appropriate metaphor and this in turn may generate more motivation in the student. It is important not to dismiss the use of metaphors, even if the evidence to date has shown that there is no improvement in the achievement, as there is more to the learning process than just the end result. For example it is important that the student enjoys their studies: if they are not satisfied with their learning experience then they may choose not to continue with their studies (Chiu, Hsu, Sun, Lin & Sun, 2005).

As well as the different ways in which a student may be introduced to a learning environment and the different layers with which they will be interacting, there are also different types of learning environments such as adaptive learning environments, which are described in the next section.

## **Adaptive learning environments**

Research has been carried out into the use of adaptive learning environments, sometimes also known as Intelligent Tutoring Systems (ITSs). In the late 1990s this research concentrated mainly on the use of adaptive navigation, but more recently the idea of adapting the learning environment to suit the needs of individual learners has become a popular research topic. Chen and Macredie's (2002) research explored the effects of a person's learning style - in this case Witkin's Field Dependence (FD) and Field Independence (FI) - upon navigation preferences within a hypermedia environment. Their results indicated that the learning style affects not only learner control and learning effectiveness but also that FD learners, who process information globally, learn better in an environment which is led, whereas FI learners, who are more analytical and process information in component parts, prefer individual learning and free exploration. Whereas led learning is well structured and the student works to a rigid plan provided to them (perhaps with the learning materials only being made available to the student once they have completed the previous step), individual learning and free exploration is where a student may have access to all the materials and choose their own route through the materials, possibly exploring other related materials as well. Chen & Macredie's (2002) findings have been supported by others (Calcaterra, Antonietti & Underwood, 2005; Lee, Cheng, Rai & Depickere, 2005; Chen & Macredie, 2004; Liu, 1994).

Not only is e-learning becoming a popular method of learning, it is technically well suited for adapting the delivery of learning materials in different ways. It has been shown that FI and FD people have different navigation needs in a hypermedia environment. Much of the work into adaptive learning environments has centred on providing for an individual's learning style. Such research includes that of Wolf (2002)

who developed a learning environment called iWeaver which was able to adapt the teaching style to suit an individual's learning style in order to teach the Java programming language in the most suitable manner for each student. Other examples of adapting the learning environment to suit the learner's preferred learning style include work by Tseng, Chu, Hwang & Tsai, 2008, Papanikolaou, Mabbott, Bull & Grigoriadou, 2006 and Triantafillou, Pomportsis & Demetriadis, 2003. There is evidence to show that matching the learning style within an online learning environment improves learning attainment (Chou & Wang, 2000) and also satisfaction (Simon, 2000). However, the evidence available is not conclusive since others such as Chen, Ryan & Olfman (2004) showed in their study, involving asynchronous software training, that there was no significant relationship between the training performance or the students' reactions to the training and their learning style.

Three major driving forces behind research into adaptive learning environments are the need to increase student motivation, improve knowledge retention and improve understanding. However, as e-learning systems become adaptable to the user's learning style, an important ethical issue arises when the system is designed to purposefully match, or mismatch, the learner's preferred learning style. On the one hand, if the learner's style is matched then the content will, in theory, be more effectively learned. However, this matching of styles may lead to the student developing an even stronger preference for this style. The opposite scenario would be to purposefully mismatch the student's preferred style, as this would then theoretically make the learning of the content less effective, but could strengthen the student's weaker styles thereby creating more flexibility in the student's learning styles. The question is who has the right to decide if the priority is for the student to learn the content efficiently (by matching their style) or to develop the student's learning ability (by mismatching their style) (Robotham, 1999; Messick, 1984).

Some research has gone beyond simply adapting the learning environment according to the student's learning style, and includes adaptability based around further individual attributes such as the learner's goals, capabilities and knowledge level (Specht, Kravcik, Klemke, Pesin & Hüttenhain, 2002; Melis, Andrès, Büdenbender, Frischauf, Gogvadze, Libbrecht, et al., 2001; Weber & Brusilovsky, 2001; Vos, 1999). However, providing this level of adaptability and support to a student normally involves the use of artificial intelligence, discussed in the following section.

### **Artificial intelligence (AI)**

The field of artificial intelligence (AI) has several uses within the e-learning context. The most obvious use of AI within e-learning would be to create a virtual instructor that has human characteristics and an ability to support and motivate students that can replicate a real instructor. Perhaps it could even be better than a human, in that the virtual instructor would never get tired or annoyed with the student's endless questions. The reality is that this is a long way into the future, although research has been carried out into the creation of an intelligent tutoring system which would adapt the level of instruction according to the student's ability (Vos, 1999). Research has also been carried out into the use of personal assistants (agents); for example a personal assistant could help a user search for appropriate web pages as Armentano et al. (2006) showed in their research. They used two different types of assistant: one where the user viewed both the pages selected by the search engine and the pages suggested by the assistant on the same screen, and one where only the pages selected by the search engine were displayed, but the assistant alerted the user that they had some suggestions and the user had to select them in order to view them. Interestingly their results showed that the latter approach was preferred by users and they concluded that this was because the users

were not expecting so much from it and were more easily satisfied with the results it produced.

There are other less obvious areas where AI can be utilised within a learning context. Cheng, Lin, Chen & Heh (2005) devised an AI system to diagnose individual and generalised class learning, thus identifying any problem areas either the class as a whole or an individual student may be encountering. It was then anticipated that the teacher could adapt the teaching level to better suit the students. One could easily foresee the potential of such a system being incorporated into an e-learning application in order to diagnose a student's learning and allow the teaching (the delivery of the learning materials) to be adapted accordingly.

Whilst there is obviously much potential for the use of AI within e-learning, a lot of work still needs to be carried out to identify the most appropriate use of this technology.

### **Affective computing**

Affective computing is an area of artificial intelligence that studies emotions and computers. Picard (1997) defined affective computing as “computing that relates to, arises from or deliberately influences emotions”. The field of affective computing is divided into two distinct areas, with one focussing upon the recognition and expression of human emotions and the other investigating the simulation of human emotions.

Jaques and Vicari (2007) indicated that it is the recognition and expression of emotions which is currently of most interest to researchers in computer-based education. This is because they are most interested in recognising students' emotions when interacting with an artificial tutor, as this would allow the artificial tutor to adapt the 'lessons'

according to the students' emotions. For example, a student who gets poor results may feel disappointed and want to give up on a task. The system needs to know the student is disappointed in order for the artificial tutor to become more encouraging.

This area of affective computing generally relies upon one key concept: the acceptance of a computer as a social actor or social partner, where a social actor may be someone playing the role of a tutor and a social partner might be a fellow student or peer. Many studies have shown that computer interfaces can be accepted as social partners (Dillon, Freeman & Keogh, 2004; Klein, Moon & Picard, 2002; Parise, Kiesler, Sproull & Waters, 1999), although it is still unclear if it is the interface, the system or the machine which is acting as the partner. The understanding of which element of the setup is the social partner may be impossible to determine as it would not be possible to have an interactive interface without having a system to make it work. Equally one cannot have a system without a machine upon which to run it. There are additional problems: the more convincing the computer is as a social actor, the more the human may expect from the computer (Dillon et al. 2004).

In Parise et al.'s (1999) study, participants played a social dilemma game with three interface agents via video conferencing. Three different interface agents were used in place of another human: a person-like agent, a dog-like agent and a cartoon dog agent. The participants, when playing the game, had to cooperate with the agent, making and keeping promises to them. They found that the more life-like the agent the more likely the participant was to cooperate and keep their promises, although dog owners were likely to cooperate and keep their promises to the dog-like agent. This was thought to be because participants were able to create a social expectation of the computer agent and in general participants had a more confident and positive social expectation of the person-like agent than the others. Again the results of this study support the theory that computers can be considered social actors.

Another element which contributes to creating a social partner is how polite the partner is. This aspect of social interaction may be very basic to code but have a very high social impact, which was clearly demonstrated in the research by Mayer, Johnson, Shaw & Sandhu (2006) in which they identified eight classifications of social politeness and applied them to a 'click here' button. For example a button was worded 'click the ENTER button' or 'do you want to click the ENTER button?' They based their predictions on the idea that learners can accept computers as social partners and apply the norms for social interactions as they would in a face-to-face interaction. These assumptions appear to have been borne out as the results showed that learners are sensitive to the politeness tone of statements from a computer-based tutor. Furthermore they found that users who had little experience with computers were more sensitive to the politeness tone than highly experienced users. One could assume that this was due to the experienced computer users being so used to working with impolite social actors that they have come to accept and ignore the impoliteness, just as one might come to accept an impolite person and say 'it is just the way they are'. However, Mayer and his colleagues do point out that further research is needed to identify if the sensitivity of the politeness tone is only a short-lived effect or not.

The use of positive or negative feedback also affects a user's emotional state as Partala and Surakka (2004) showed in their research in which the users' reactions were monitored by measuring the electrical responses to the muscles involved with smiling and frowning. When the computer system stopped responding to the users, a synthesized verbal intervention was provided which was either a positive intervention such as "great, the computer will work again soon" or a negative intervention such as "that is frustrating". The verbal responses were synthesised voices which were made as neutral as possible so that the positive and negative intervention was purely in the wording. There was also a group in which no intervention at all was provided. The



findings indicated that intervention of either a positive or negative nature created a more positive reaction in the user than no intervention at all, and that a positive intervention created a more positive reaction than the negative interventions (Partala & Surakka, 2004). These findings are supported by work carried out by Klein et al. (2002), whose study into user frustration showed how even if the system was the cause of the frustration, by using affective support this frustration could be alleviated. They achieved this by creating a game which had a delay built in. This delay was apparently a web or network delay that occurred while the user was playing the game. At the end of the game the user could interact with the computer via a questionnaire and text input. There were three different interaction conditions: ignored - a questionnaire with no means of reporting the delays or user feelings; vent - a questionnaire which provided the opportunity for the user to report their feelings; affective-support - a questionnaire that included affective-support for the user to report delays and express their feelings. Upon completion of the questionnaire the user was invited to play again, this time with no delays; the amount of time spent playing the second time around was used for the measure of 'acceptance'. The results showed that when affective-support was provided the users played for significantly longer than for vent or ignored. Oatley (2004) discussed the importance of mirroring the user's emotions as a means of affective support, even when emotions have been elicited by such basic means as the user selecting the appropriate emotion from a scale.

It should be noted that the basic concept of using AI and affective computing combined as a tutoring system is not new. However, it is only fairly recently that research in this area has become more popular with studies such as that by Sarrafzadeh, Alexander, Dadgostar, Fan & Bigdeli (2008), in which they describe the development of an Affective Tutoring System (ATS). This system provides tutoring for primary level mathematics with a life-like agent. This research explored some of the elements that a

virtual instructor would require, such as being able to adapt to the student's emotional state if they showed signs of being confused, frustrated or angry.

While it is still early days for ATS systems, the use of multimedia in e-learning applications is far more established. The following sections will look at various aspects of multimedia.

## **1.2 The use of multimedia in e-learning**

In general, the term 'multimedia' is used to describe the inclusion of several media types in an application, such as text, video, audio, images and/or graphics.

The use and complexity of multimedia has increased alongside the capacity of computer memory, bandwidth and general computer specifications. In the early 1990s, the use of video or 3D animation in a general e-learning application would not have been viable due to limited computing power in PCs. However, now it is commonplace to incorporate video, complex graphics or images. Complex graphics, and computer-generated 3D animations, that can depict complex structures and show them from various angles, are particularly useful within the science domain where there is a need to show complex 3D structures, e.g., a graphical representation of the internal organs of a human. 3D graphics is now being used in e-learning for the creation of authentic learning environments, virtual reality environments (Miskovic, Rosenthal, Zingg, Oertli, Metzger & Jancke, 2008; Depradine, 2007) and to encourage greater social interaction online (Barbieri, Barchetti, Bucciero, Mainetti & Santo Sabato, 2006; Bourns, Hornig, Triantafillou & Tsiatsos, 2001). Authentic learning environments often make use of virtual reality and social interaction tools in order to provide an environment that simulates a real life situation, such as operating on a patient (Beux & Fieschi, 2007; Alexiou, Bouras, Giannaka, Kapoulas, Nana & Tsiatsos, 2004) or playing the role of a

junior advisor to a company (Gulikers, Bastiaens & Martens, 2005). The use of such authentic learning environments allows the learner to gain appropriate experience in a safe but realistic situation. Not all e-learning applications make use of such complex multimedia elements, often due to the cost of producing such media. Some researchers have examined the use of less complex multimedia elements. For example Plass, Chun, Mayer & Leutner (2003) studied the use of verbal and visual annotations for students learning a second language via an e-learning application. They found that the text comprehension was worse for learners when they received the visual annotations. The results from this study offer support to Mayer's Cognitive Theory of Multimedia Learning (CTML), which describes several principles for multimedia learning. These include the following principles that Moreno and Mayer (2007) described:

- *Guided activity*: students learn better when allowed to interact with a pedagogical agent who helps guide their cognitive processing.
- *Reflection*: students learn better when asked to reflect upon correct answers during the process of meaning making.
- *Feedback*: students learn better with explanatory rather than corrective feedback alone.
- *Pacing*: students learn better when allowed to control the pace of presentation of the instructional materials.
- *Pretraining*: students learn better when they receive focused pretraining that provides or activates relevant prior knowledge.

Further principles that Mayer and Moreno (2003) and Mayer and Moreno (1998) had previously described included:

- *Multiple Representation*: It is better to present an explanation in words and pictures than solely in words.
- *Contiguity*: When giving a multimedia explanation, present corresponding words and pictures contiguously rather than separately.
- *Split-Attention*: When giving a multimedia explanation, present words as auditory narration rather than as visual on-screen text.
- *Coherence*: When giving a multimedia explanation, use few rather than many extraneous words and pictures.

Although these CTML principals have been used to good effect in some applications (Gemino, Parker & Olnick Kutzschan, 2005; Plass et al. 2003), other research such as that carried out by Moreno & Valdez (2005) and Westelinck, Valcke, De Craene & Kirschner (2005) has shown that these principles are not effective in certain domains. In particular, Westelinck et al (2005) showed how the use of CTML principles for designing multimedia content within the domain of social sciences did not improve the students' results and in some cases their results deteriorated. They indicated that this may have been because the social science domain does not generally use many symbolic representations unlike the science domains where there is much use of symbolic representations, drawings and images.

It is generally assumed that animation refers to moving pictures on screen. However, there is now a blurred boundary between animation and temporal or dynamic typography, which is text that moves or changes its form in some manner. Traditionally text was a group of static letters to be read and an animation was a moving image to be watched. However, since the early days of films when credits started to move down the screen, the distinction between the two has become increasingly blurred, with more

creative and imaginative ways of moving text on screen being produced (Bachfischer & Robertson, 2005). There have always been ways of elaborating text to enable expression beyond the words alone, for example the use of bold text to emphasise a particular word. However, some have gone much further and are using movement, changing the size and colour of text, even changing the form of the letters into other objects, to create additional meaning (Wong, 1996) and to enable the expression of the writer's emotions (Hua, Helmut & Takeo, 2004; Forlizzi, Lee & Hudson 2003). The use of dynamic typography has also been used in more artistic applications as discussed by Bachfischer and Robertson (2007). With the increasing use of multimedia and Internet resources for educational purposes, it is no surprise that this has led to an increase in the use of temporal typography within educational settings than has traditionally been seen with print based resources (Borzyskowski, 2004). There is much potential in the use of temporal typography: for example Back, Cohen, Gold, Harrison and Minneman's (2002) research demonstrated that 'flashing' a word or phrase onto the screen followed by the next word or phrase being 'flashed' onto the screen in the same location (a process known as Rapid Serial Visual Presentation) could increase the reader's average reading speed 3-4 fold, with the average speed of 300 to 400 words per minute being increased up to 2,000 words per minute. The users controlled the speed the words flashed at and were able to increase or decrease the speed as they wished. It was theorised that the eyes are able to stay focused in one place on the screen and do not need to move and locate the next visual target, hence allowing faster reading. It has been suggested that it is time our understanding of 'type' (i.e. text) be re-evaluated as when one refers to text it is still assumed to be static in nature, with some properties of colour and form, but this assumption is becoming outdated (Brownie, 2007). Despite the increasing use of temporal typography in many different domains and its potential benefits, there remains a limited amount of research into its effects upon the

reader/viewer (Hua, Helmut & Takeo, 2004). This is also the case for multimedia elements and their effects upon learners, and whilst there is a growing amount of research into affective computing, little of this research is aimed specifically at the multimedia elements. Astleitner (2004) highlights that while there are theoretical models concerning multimedia, motivational and cognitive processes, there is a lack of published research into the emotional effects of multimedia within learning environments. He also points out that whilst the computer games industry is well aware of, and uses, the design of multimedia to manipulate a player's emotional state, it is generally for the stimulation of negative emotions such as anger or fear. This does however provide an indication that multimedia elements can be used to affect the user's emotional state.

So far various visual types of multimedia and their uses have been described; however, audio is also a type of multimedia and the next section will look more specifically at the uses of audio within computer interfaces.

### **1.3 The use of audio in interface design**

The use of audio within computer interface designs has been somewhat overshadowed by the graphical aspects of interface designs, particularly with the introduction of the Graphical User Interface. Although the use of audio elements has been present for a long time, it has often been simplistic in nature. However, as the quality of sound reproduction has improved, the use of audio within interface design has begun to capture the attention of researchers. The following subsections examine current research into the use of audio within computer interfaces.

## **The use of non-linguistic audio communication in the computing domain**

Non-linguistic audio communication in the computing domain can be categorised into two groups: the communication of intangible things such as emotions and moods and the communication of more tangible information, such as a 'xy' coordinate position on screen or to indicate some action, e.g., a sound that indicates that you are shooting someone in a computer game. Most of the research into the use of audio within interface designs has concentrated upon the communication of the tangible information, as described in the next section.

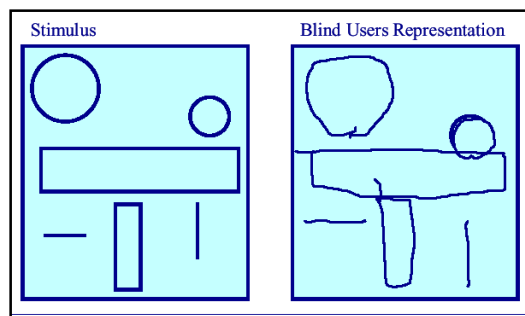
### **Communication of tangible information**

There are already many interfaces which make use of sound in some manner. Even the most basic computer will use sound; for example when booting up the computer the user will be alerted by a 'beep' if something is wrong. Sound can also be used to communicate more than just warnings. Earcons are an audio equivalent to icons and are often used by blind people. They use a distinctive sound to represent different items, e.g., different types of files and folders, rather than the distinctive visual pictures used for icons. They can be used to aid navigation (Blattner, Sumikawa & Greenberg, 1989; Brewster, Wright & Edwards, 1993b).

Other research such as that of Alty, Rigas & Vickers (1997) has examined the use of audio and music for communicating information by using musical components in a computer program during the debugging process. Different tunes were played as the program entered each structure: for example a rising pitch was played as a FOR LOOP was executed and a distinctive timbre and pitch would be related to an IF THEN clause. The theory behind this experiment was that the musical representation of the code could

highlight ill-formed structures within a program. Early results showed that the users could distinguish the different structures. Alty (1995) also carried out experiments on the use of audio for the description of algorithms. He used audio sounds to represent the numbers and the different processes occurring within a bubble-sort algorithm and also a travelling salesman algorithm, with his results showing a very good understanding for the bubble-sort and a fair understanding for the travelling salesman.

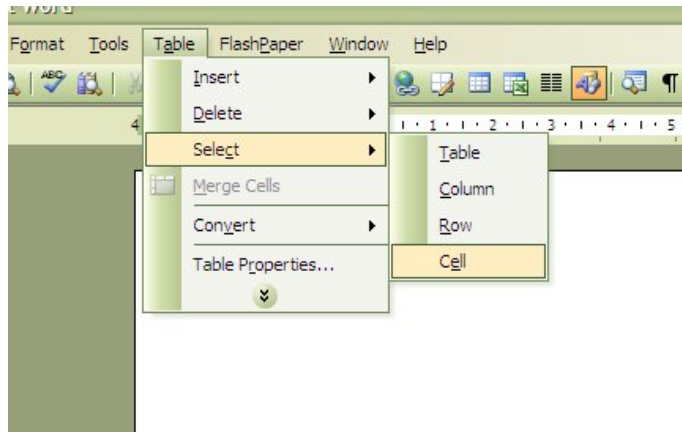
A further study carried out by Alty, Rigas & Vickers (2005) researched the use of an audiograph system in which they mapped screen coordinates using sound. They used a drum sound for attention, a piano sound to map the X coordinate and an organ sound to map the Y coordinate, and the X and Y coordinates were expressed using a rising sequence. A blind user was asked to listen to various shapes on the screen being played and then asked to draw their representation of what they heard. The results were impressive, although only one result was shown in the paper (Figure 1.1).



**Figure 1.1 A Blind User's Interpretation of a Stimulus (Alty et al, 2005)**

Alty also identified another slightly different type of mapping, which was of a history, as might be found in the visual domain of a menu such as in a Word application. Figure 1.2 shows a visual representation of a history pathway. Here the user has navigated through the menu and selected: *Table>Select>Cell*. Visually this pathway is clear to see but it is much harder to represent in an audio domain.





**Figure 1.2 A visual representation of a history pathway**

However, it might be possible to use repeating sounds like those used in the song ‘Frere Jacques’ or ‘Row, row, row your boat’. Alty believed that it would be possible to create an audio history mapping, as humans are very proficient at parallel-processing audio information (Alty, 1995). Coleman, Hand, Macaulay & Newell (2005) carried out a study into the use of audio in computer games and indicated how the process of audio creation should not be an add-on at the end, but that it is an essential and integral part of the design process. They observed that the audio information being conveyed to the user sometimes called for a redesign of the game itself. For example if the player and the enemy were shooting the same type of gun, the user would not be able to distinguish who was shooting and so the game would have to be redesigned to ensure different gun sounds were always used. These studies have shown the potential of audio to be used as an effective medium for the communication of tangible information.

### **Communication of intangible information**

Although research has been conducted for a number of years into affective computing, this has mainly been in the area of communicating emotions via textual content (Jaques

& Vicari, 2007; Mayer et al. 2006; Partala & Surakka, 2004; Klein et al. 2002). There has also been research into the expression of emotion within synthetic speech, i.e., how it is said. The same phrase could be said with a happy emotional voice or with a sad emotional voice. For example when talking to a person on the phone it is possible to understand the other person's emotional state just by listening to how they say their words, and this indicates that emotions can be communicated by the way words are spoken. However, it is proving to be difficult to replicate the emotional meaning in synthetic speech (Murray & Arnott, 2008; Bosch, 2003).

Some research such as that carried out by Sutton and Lowis (2008) and Lemmens (2005) has shown that it is possible to communicate emotional information via non-verbal audio. Both studies identified minor chords as portraying negative emotions and major chords as portraying positive emotions. Others have also identified emotional content within music, such as a piece of music being perceived by the user as happy, sad, active or calming (Brader, 2005; Hallam & Price, 1998; Robertson, de Quincey, Stapleford & Wiggins, 1998).

This chapter has described how e-learning environments can provide a wide range of facilities to students. These facilities can allow students access to learning materials and to communicate with teachers and peers from anywhere at anytime, making learning more accessible and in many ways more cost-effective than traditional classroom-based learning. It is understood that e-learning environments do not cater for all the needs of the learner and that there are drawbacks to e-learning such as a potential lack of sufficient social support which can lead to student frustration.

The e-student was then described and some of the attributes that contribute to the student's uniqueness were examined. It has also been described how researchers are

attempting to make use of adaptive environments, artificial intelligence and affective computing to provide e-learning environments that can cater for the wide ranging needs of the individual learner.

The use of multimedia within e-learning environments was described; this included the use of non-linguistic audio as a means of communication. Here it was identified that emotional content can be communicated by musical chords. However, there appears to be little research into this particular use of multimedia, despite its potential as a means of enhancing communications by adding a further dimension of emotional content.

The concept of music communicating emotions is expanded upon further in the next chapter where some of the uses of music are explored and human emotions are examined in more detail.

## **CHAPTER 2**

### **MUSIC AND HUMAN EMOTIONS**

In the previous chapter the use of audio in computer interfaces was described. In order to enable further investigation of the potential uses of audio, the first section of this chapter will examine the way in which music is used in society to influence or affect people. It is worth noting that when describing music and society this refers to Western society and music that is commonly listened to within the Western society. The second section of this chapter looks further at emotions, discussing what they are and how they can be categorised.

#### **2.1 What is music?**

Music can be considered as an audio experience. However, audio is generally split into two categories; sound and music. It is important to clarify the distinction between music and sound.

#### **The difference between music and sound**

It is widely accepted that a single note would be classified as a sound and not as music, but at what point does sound become music? In general, sound is defined to be a measurable vibration. It can also be defined as “meaningless noise”<sup>1</sup>. In contrast, music

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<sup>1</sup> <http://www.thefreedictionary.com/Soundable> [Date accessed 3/4/2008]

is generally considered to consist of some form of organised sound. Table 2.1. shows some definitions of music.

**Table 2.1. Definitions of music**

Definition of Music	Source retrieved from
<p>“The art of arranging sounds in time so as to produce a continuous, unified, and evocative composition, as through melody, harmony, rhythm, and timbre.”</p> <p>“Vocal or instrumental sounds possessing a degree of melody, harmony, or rhythm.”</p>	<p><a href="http://www.thefreedictionary.com/Soundable">http://www.thefreedictionary.com/Soundable</a></p> <p>[Date accessed 3/4/2008]</p>
<p>“A succession of sounds possessing measurable qualities such as pitch, duration and intensity, as well as the not so easily measurable dimensions of timbre and the movement across time”.</p>	<p>Landry (2004, page 28)</p>
<p>“Organised auditory information”.</p>	<p>Csikszentmihalyi (1991, page 109)</p>

Whilst it is almost universally accepted that music does convey emotional content, there is debate about whether the emotion conveyed by music is expressed in such a way that the listener is perceiving or recognising the emotion, known as the cognitivist view, or whether the music conveys the emotion in such a way that the listener actually experiences the emotion. Although there is evidence to support both views there seems to be more support for the concept that the listener experiences the emotion (Robertson et al. 1998; Krumhansl, 1997). Studies using physiological measures indicate that the emotions conveyed by music can induce physical changes. An example of this is the study by Krumhansl (1997) who showed that sad excerpts of music produced the largest

changes in heart rate, blood pressure, skin conductivity and temperature in the listener. While fear excerpts produced changes in blood transit time and amplitude, with happy excerpts he found the largest changes were in the respiration rate of the listener.

## **2.2 Current uses of music in society**

Whether one takes the cognitivist view or not, there is little disputing the fact that music can have some effect on the listener. This ability of music to affect the listener has been utilised in several areas of society, with examples including the use of music in film and television, advertising and marketing, therapy and learning. The following sections discuss some of these uses of music.

### **The use of music in film and television**

One of the most well-known examples is the use of music in the film and television industry. The use of both sound and music in this industry is well understood, and two modes in which sound or music is used have been identified by Robertson et al. (1998) as follows:

- *Diagetic* - this occurs within a scene (e.g. sound or music coming from a radio within a scene).
- *Non-diagetic* –music which the characters within the film cannot hear, but the viewers can. This is usually used to convey emotion about a scene.

The use of music to either enhance or alter an emotional state is common practice in the film, TV and advertising industries. Most of us will have experienced the emotion of

fear when watching a horror film or of sadness during a drama. What one may not have fully appreciated is the immensely important role that music plays in evoking one's emotional responses.

A well-known example that highlights this importance is when the horror film "Psycho" was released and there was an outcry that the shower scene was too horrific (Millbower, 2003). However, when the scene was examined in more detail it was noticeable all the viewer saw was a knife waving around and blood pouring down the plughole. At no point was the knife seen to be stabbing the victim. The shower scene was not so horrific after all. What created the sense of horror in the scene was the disturbing music and some very clever directing. Another equally well-known film is Jaws, and again it is music that instils fear in the viewer far more than the rippling water under which a shark is thought to be lurking.

There is no doubting the fact that films and television programmes do not have the same impact upon viewers without the accompanying music. This could be seen in the days of the silent movies. When they were first introduced to the public in 1896 they were a novelty and were much enjoyed. Some of the larger theatre owners had musicians playing along to the silent movies. Once the novelty of the silent movies wore off it was clear that the silent movies with accompanying music were much more successful than those without (Millbower, 2003).

### **The use of music within marketing**

Within TV advertising, music is a key element in selling a product. Hung's (2001) study into the effect music can have upon the perceptions of a TV advert took the same 'film',

an advert for a shopping mall, and played different musical soundtracks along with the advert. They used classical and rock music, using subjects who had not seen the advert or heard about the shopping mall previously. The results clearly showed how the different soundtracks completely altered the subjects' perceptions of the advert and therefore the product. When seen with the classical soundtrack the subjects perceived the advert to be showing a very classy mall that used soft light colours and cut smoothly from one shot to another. When viewed with the rock soundtrack the subjects perceived the mall to be a very vibrant place, with the advert using bright contrasting colours and some subjects complained that the cuts from one scene to another were too quick. This study illustrated how the different musical tracks altered not only the general perception of the advert, but also the perception of the length of the advert, the colours used, and the length of the scenes. In some cases different focal points were observed throughout the advert.

Hung (2001) also drew some comparisons between how a headline in a newspaper can alter the viewer's perception of a picture with the way music can change a viewer's perception of a film clip, be it a movie film or an advert. For example, a picture of a man holding lots of money accompanied by the headline "A Hard Working and Clever Man" may cause the reader to admire this man as he has probably worked hard to earn this money. However, the very same picture with the headlines "Man Killed Wife" may cause the reader to dislike this man perhaps provoking thoughts that he may have killed his wife to get this money.

In a similar manner to the use of music within TV adverts, music is also used in retail stores. Garlin and Owen's (2006) research showed that the tempo, volume and familiarity of the background music being played had an effect upon customers' length of stay, rate of spend and quantity of goods purchased in a retail store.



It should come as no surprise that just as the advertising and marketing industries have come to understand the power of music, so too have political campaigners. Brader's (2005) study into the use of music to help manipulate the voters' emotions revealed that music was used along with imagery to create desired emotions. The idea was that the imagery and music could be associated with good times and used to reinforce the salience of prior beliefs. The other desired emotion is that of fear which again uses imagery and music, this time associated with threat, which decreases salience in prior beliefs, and motivates a new choice, hopefully a move away from an opposing political party towards their own. Brader recognised that the art of electioneering lies as much in how that message is delivered as in getting the message out.

### **The use of music in therapy**

Some of the most compelling evidence for the concept that the listener experiences the emotions conveyed by the music is provided by studies such as that by Blood and Zatorre (2001), which examined music's effect upon the workings of the brain. They found that music stimulates the same areas of the brain as reward and emotions, similar to those which are stimulated by food, sex, and drugs. They concluded that although music is not an imperative for survival in the way food and sex is, it may be needed as it apparently can contribute to our mental and physical wellbeing. Stefano, Zhu, Cadet, Salamon and Mantione, (2004) and Salamon, Kim, Beaulieu and Stefano (2003) have shown that chemical changes in the brain are triggered by listening to music and such changes can have biological affects upon the human body, such as lowering blood pressure. Building upon the idea that music can have an effect upon people, music has been used as a form of therapy as Hallam and Price (1998) demonstrated when they played carefully selected background music to children suffering from an assortment of

behavioural problems, in particular hyperactivity, while the children were participating in classroom activities. Those who were normally disruptive were apparently calmer and less disruptive and more focused on their work when the music was playing. Other similar research such as that carried out by Lundqvist, Andersson, and Viding (2009) and Sausser and Waller (2006) has supported these findings. It has been suggested that the background music may have served sufficiently to satisfy their stimulus hunger whilst not distracting them from their ability to concentrate on the task. The next section describes a similar use of music, but in a learning context rather than a therapy context.

### **The use of music in learning**

There has been much research carried out into the effects of music upon learning, some of this dating back to the 1930s. For example, Fendrick (1937) demonstrated that the use of background music impaired students' retention compared to when no music was played. More recently the use of music to enhance learning has received much publicity. In particular the "Mozart effect" has brought the use of music to enhance learning into the spotlight. The term "Mozart effect" first appeared in the early 1990s and is thought to have its origins in the work of Alfred Tomatis who used recordings of Mozart's music to help alleviate problems through the auditory channel. Later research into the Mozart effect generally refers to an increase in the spatial-reasoning performance of a person immediately after listening to a piece of Mozart's music. Interest in the Mozart effect has led to several scientific studies to find evidence to support it. However, the findings seem to be very inconsistent, with some results supporting the Mozart effect (Jausovec, Jausovec & Gerlic, 2006) while others do not (McKelvie & Low, 2002; Steele, Bass & Crook, 1999). Although the reason for these inconsistent results may be

in part due to the different processes and measurements employed in the tests, Talero-Gutierrez, Zarruk-Serrano & Espinosa-Bode (2004) pointed out that where an effect was seen when Mozart music was played, the effect was often only short-lived and only for very specific tasks.

Others have researched the use of music on learning in a broader manner by using different types and styles of music, such as classical and pop. Examples of these include Miskovic et. al (2008), whose study investigated the use of background music while novice surgeons were learning laparoscopic procedures using a virtual reality simulator. They found that the music had a distracting effect when the novice surgeons were performing new procedures and recommended that music be turned off in these situations. However, others have shown that playing background music can have a beneficial effect (Bennet & Bennet, 2008; Hallam & Price, 1998; Sedighian & Sedighian, 1997). Hallam and Price (1998) showed that research dating back to the 1950s gave indication that use of music could increase academic achievement by seemingly improving concentration, mood and accuracy. There are many different ways in which music can be used in a learning environment. Seidman's (1981) review of literature into the contributions of music in television and film productions identified several aspects of the use of music in instructional productions that are often overlooked, such as how the use of music can enhance the meaning of the visual elements. However, if the music is poorly matched to the visual elements then this can confuse the viewer. He concluded that the viewer's perception of the media message could be altered by the music accompanying the visual media, depending upon the music type and the nature of the message being conveyed.

It is also worth discussing the changing nature of students, since much of this research into the use of music is dated and students of today are more exposed to technology than students of 20 years ago. Thus it is debatable if the results from these older studies are

still applicable to today's students. Prensky (2001) describes the younger generation of today as digital natives; in other words they have grown up with technology: playing videogames, watching TV, communicating with friends via mobile phones, instant messaging and email, and so forth. This view is shared by Kennedy and Krause (2008) who referred to the use of these technologies as 'entrenched technologies and tools'. Due to the nature of this generation's exposure to technology they learn in a different way to their parents. Prensky believes that students of today are less distracted by background media, such as having the TV on in the background while studying, as they have grown accustomed to information being directed to them via multiple channels and they are able to focus their attention where they want (Prensky 2001a, Prensky 2001b).

### **The use of music within e-learning environments**

The use of music in e-learning environments is a largely unexplored area, with only a few studies to date including that carried out by Robertson et al. (1998) who used music to create fear and suspense in a 3D learning environment. This learning environment to allow children to improvise whilst creating a play in a 3D horror house using music to create suspense and tension. They found that the students' learning was improved due to increased motivation. They believed that this improvement in motivation was due to an increased sense of presence, that is, the students felt more a part of the environment.

In an attempt to support a learner's emotional state, Chaffar and Frasson (2004) described an architecture developed with the purpose of determining the individual's optimal emotional state for learning. This architecture then makes use of music along with images to induce an optimal emotional state for learning. Another study that made more direct use of music was carried out by Sedighian and Sedighian (1997), who used music in an electronic learning environment for teaching mathematics. Their results

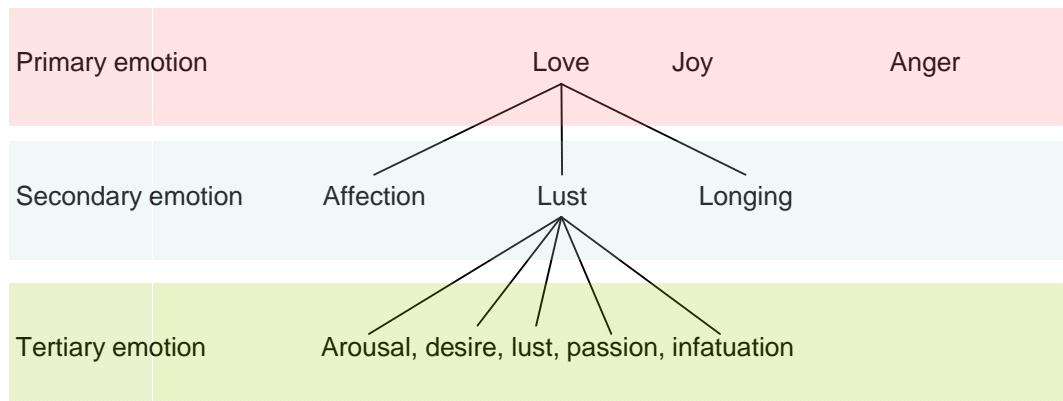
clearly showed that more than 85% of the participants either liked or loved the music. An improvement in the learning achievement scores was also seen when the music was playing.

It has been described here that there are many ways in which music is used in society to influence people. This influence more often than not involves affecting a person's emotional state. The next section goes on to describe emotions and emotional states.

### **2.3 Emotions and their influence upon learning**

In order to understand more about emotional states this section describes various categorisations of emotions that have been put forward and considers these emotions within computing environments and upon learning.

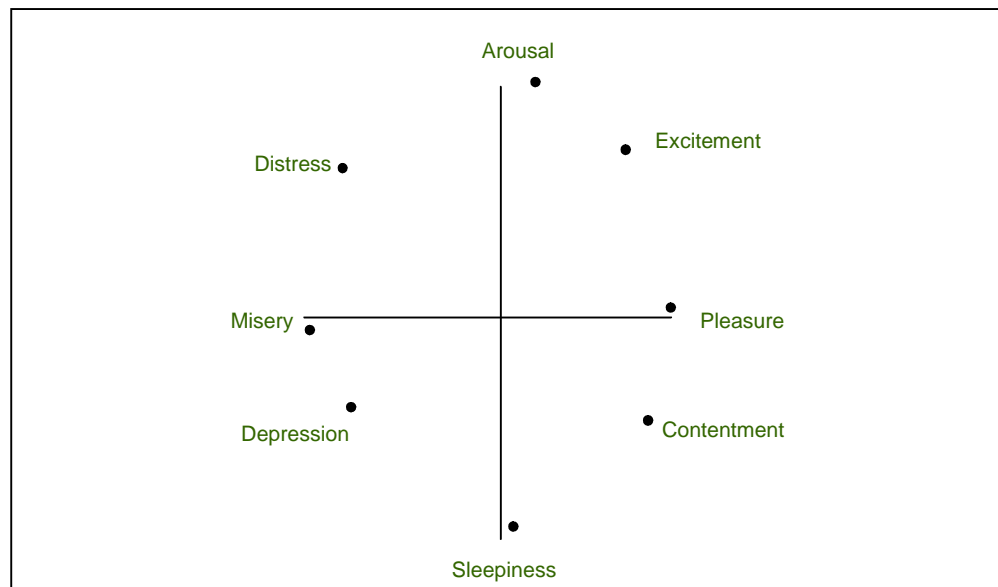
The study of human emotions is not an exact science and many different emotional models have been suggested. Some theorists categorise just the basic emotions, the most commonly identified of which are: Anger, Fear, Happiness, Love and Sadness (Ortony & Turner, 1990). Other theorists such as Parrott (2001) not only categorise basic emotions but also secondary and tertiary emotions. Parrott described an emotional tree structure which encompassed the different levels of emotions. Figure 2.1 provides a representation of this tree structure, following the love and lust branches to the tertiary level of emotion.



**Figure 2.1 A visual representation of an extract from Parrott's emotional tree (Parrott, 2001)**

Posner, Russell & Peterson (2005) have suggested that rather than attempting to categorise each emotion, a more fitting conceptual model would be a model of affect. This model provides an axis of pleasure and an axis of arousal along which many of the commonly recognised emotions are placed. They suggest that many recent findings from behavioural, cognitive neuroscience, neuroimaging, and developmental studies of affect fit more consistently with the circumplex model of affect originally described by Russell (1980) and reproduced in Figure 2.2.

The lack of agreement over how best to categorise emotions could be due to the difficulties in accurately recording or measuring emotions. This lack of a firm scientific understanding of emotions is eloquently discussed by Fehr and Russell (1984, p. 464) where they highlighted the difficulty in defining emotions by saying “everyone knows what an emotion is, until asked to give a definition”.



**Figure 2.2 A representation of the circumplex model of emotions by described by Russell (1980)**

It has also been proposed that there is a difference between feelings, emotions and moods. Landry (2004) described a feeling as an emotion that is directed internally and has no external stimulus. An emotion on the other hand does have some form of external stimulus, and a mood he described as a long-term emotional state. Lang (1995, p. 372) described emotions as action dispositions, which he goes on to further describe as “states of vigilant readiness that vary widely in reported affect, physiology, and behaviour”.

Emotions are intertwined with many other aspects of the human existence. For example, Zhang and Li (2004) believe that affect and cognition are both part of human information processing systems. With the affective system using emotions, and the cognitive system using logic to assess the surrounding environment

It is only recently that within the design of computer applications (especially games) the user's emotional state has become recognised as an important issue. Research exists that shows satisfied users are more productive (Petty, McGee & Cavender, 1984), with the additional idea that satisfied users will return to use an application or web site (Hsu & Chiu, 2004; Bhattacharjee, 2001). One could assume that these same principles could be applicable to an e-learning application. In addition there is the concept of an optimal emotional state for learning. For example if a learner's emotional state is a sad one then evidence suggests that their prospective memory performance is decreased (Kliegel, Jager, Phillips, Federspiel, Imfeld, Keller & Zimprich, 2005). Kort, Reilly and Picard (2001) also refer to the emotional state of the learner, suggesting that a positive state enables broader forms of thinking, which are good for creative problem solving. Others have also made strong connections between the learner's emotions and their learning process (O'Regan, 2003; Sylwester, 1994).

The use of music in society has been discussed in this chapter along with some of the potential uses of music, in particular, within an e-learning context. It is clear that music can have a powerful effect upon the listener and this can be used to influence the listener in different ways - in particular, music can be used to modify the listener's emotional state. The emotional state of learners has also been considered in this chapter and evidence suggests that the emotional state of a person can play an important part during the learning process, yet there appears to be little research into the emotions of e-students.

The next chapter poses the research hypothesis and details a pilot study that was carried out. It also highlights issues that can be encountered when carrying out tests within an online environment.



## **CHAPTER 3**

### **RESEARCH AIMS, ONLINE RESEARCH ISSUES AND PILOT STUDY**

The previous chapters have discussed how music can have a strong influence over the listener in various environments and how a user's experience with a computer interface can affect their satisfaction of the interaction. Placing this within an e-learning context, there is the potential for a learner's interaction experiences with the interface to influence their emotional state and their learning attainment. It was also discussed in chapter 1 how there has been little research to date into the effects of temporal typography and animations upon the viewer. This research will explore the affects of temporal typography and animations choreographed to music within an e-learning application. Since there is not a clear distinction between temporal typography and animation, from this point forward only the term animation will be used to describe both temporal typography and animations.

#### **3.1 The research aims**

The aim of this research is to identify if the inclusion of music and animation in an interface design can influence learners' emotional states and learning attainment in an online environment. Throughout the rest of this thesis, the term 'interface design' will relate to the method of delivering the content rather than the other levels of interaction with the interface, such as the web browser or the hardware, as described in chapter 1. The following research question forms the foundation for the rest of the work described in this thesis:

*Does the inclusion of music and animation in the interface affect a learner's perception of their emotional state and their learning attainment in an e-learning environment?*

The learner's perception of their emotional state was considered to be important since previous research has shown connections between the learning process and the learner's emotions (Kliegel et al., 2005; O'Regan, 2003; Kort, 2001; Sylwester, 1994).

### **Experiment development**

To enable the hypothesis to be tested, a series of experiments were developed. The following research design was used: firstly a pilot study was carried out in order to establish the feasibility of using music and animation within an e-learning environment. This was followed by a test designed to identify suitable music for use in the music and animation study. On completing the music and animation study two further experiments were carried out, one to obtain qualitative data in order to provide a deeper insight into the results and another to provide further validity of the results from this main study.

This research aimed to identify the effects of music and animation upon learners in an e-learning environment. It was considered more appropriate to conduct the experiments in an online environment rather than in a classroom setting. It was important for the experiment to be conducted in as 'natural' an environmental setting as possible, in order to ensure a participant's emotional state was not unduly influenced by the environment. However, conducting research online is not without its problems, and these are discussed in the next section.

### **3.2 Online research issues**

There are common problems associated with any type of research, including research carried out in a very controlled laboratory setting. However, carrying out research in an online environment has its own unique set of problems, as well as some benefits (Kraut, Olson, Banaji, Bruckman, Cohen & Couper, 2004; Duffy, 2002; Nosek, Banaji & Greenwald, 2002). This section discusses the benefits and problems of carrying out research in an online environment, as well as some strategies for overcoming these problems.

#### **The benefits of online research**

When carrying out research in an online environment there are some obvious benefits, such as being able to have any data collected entered automatically into a database. This can be a very effective method of collecting large quantities of data as it does not require researchers to spend a lot of time eliciting data from participants. Additionally, the researchers would not have to input data into a database, saving time and potential topographical/keystroke errors. There is also the added advantage of removing the researcher from any face-to-face interaction with the participant, a source of concern for many experimental designers as the researcher may inadvertently influence the participant. Data, such as the time the test was taken or the amount of time the test takes to complete, can be easily obtained. Anonymity in the online environment is easy to achieve, which in turn may make the participant feel more at ease. Other less obvious benefits include the ability to target specific groups or the general populace. This can be achieved by circulating an invitation on the web where it can reach a wide section of the

general populace. Alternatively, an invitation can be distributed to specific groups on the web thereby targeting desired subsections of the population (Kraut, et al., 2003; Nosek et al. 2002). Researchers have also shown that computer-based interviewing can bring added benefits, such as being a valuable tool for eliciting sensitive or personal information from a participant. This is because the computer is often considered by the interviewee as being non-judgemental and not easily embarrassed and they therefore feel more comfortable providing honest answers to delicate questions (Hands, Peiris & Gregor, 2004; Greist, Laughren, Gustafson, Stauss, Rowse & Chiles, 1973).

### **The problems of online research**

Two of the most obvious problems encountered are:

- 1) Not knowing where the participant is.
- 2) Not knowing what is going on around the participant as they participate.

For example, a participant may be sitting at home using a laptop and the radio may be playing in the background, or they may be using a mobile device whilst on their daily commute to work on the train. These varying environments may affect the way in which the participant interacts with and responds to an online experiment. Unless the target group of participants is very specific and a timetable of the experiment is laid out, e.g., college students to participate in an experiment between 1pm and 2pm, it is unlikely that the researcher can ensure that the participants are all in similar environments. In addition to this there is the potential problem of not knowing whether the participant is alone or if they are in company, and how this may influence the participant's answers. For example, they may have help answering a question they are unsure about or else

peer pressure could influence a participant's answers if they were with friends while taking the test. One could imagine a situation where a person may not want to answer a question truthfully whilst in the presence of their friends if their answer were not to conform to their friends' ideas. However, the person might happily answer the question truthfully if alone.

In face-to-face interviews, focus groups or during observations, the researcher can collect a lot of data by observing participant behaviour and reaction, although often this is not formally recorded. It is not generally possible to collect such potentially valuable data in an online environment unless webcams or other recording devices are to be used and it is not always feasible to do so where participants are accessing the tests remotely since they may not have the necessary hardware. Such data could be recorded using webcams or recording devices but workstations with the appropriate hardware and software would be needed. Data about a participant's behaviour within the interface can be recorded, such as which buttons they pressed and in what order, or how long they spent on each screen. However, without the observation element it is difficult to know exactly what the participant is doing at any given time. For example, did the person really spend five minutes viewing a particular screen, or did they leave the computer, perhaps to make a cup of tea?

Additionally, if any technical problems are encountered by the user during their participation in an experiment this has the potential to affect their responses (Klein et al., 2002; Scheirer, Fernandez, Klein & Picard, 2002). For example, if the participant experienced a particularly slow download time this could lead them to become bored or frustrated prior to or during the test.

Another problematic area is identifying the level at which the participants respond to the online experiment. As discussed earlier a user must interact with several layers during an online experience, such as the hardware, the software, the web browser and the web

content. There is the potential for participants to have problems with, or lack experience in using, particular hardware, software or browser; and this may affect how they respond to the content. Problems of this nature are not normally encountered in a paper-based environment as most people are familiar with the use of paper and pen.

The level at which the participant is controlling the protocol of the experiment can also be a problem. For example, the researcher may want and expect the participant to start by answering the questions on screen 'a', then progress to screen 'b', followed by screen 'c', etc. However, the participant may start on screen 'a', progress to screen 'b', and then use the browser 'back' button to return to screen 'a' again.

The use of questionnaires delivered online, as opposed to those that are paper-based, raises another unique problem. In both paper-based and online versions of questionnaires there is the issue of question design. However, in an online environment the use of drop-down boxes forces the participant to make a selection from a drop-down list (especially as a default selection is always made). Without an 'opt out' option provided, such as 'I don't know' or 'none of these', the participant may be forced to select an inappropriate answer. In a paper-based questionnaire this problem does not occur, because they could just choose to leave the answer blank, or write in their own answer if there were no appropriate answers to select from.

Lastly, as with many paper-based questionnaires completed in remote locations, there is no means of knowing if the questionnaire was filled in by the participant alone, or if they had help or input from others.

These key issues of online research can be categorised into four main groups; the environment, technical issues, question design and experimental protocol.

Below is a summary of each of these outlining the potential problem and a strategy to overcome the problem:

### **The environment**

#### i) Participant environment

*Potential problem* - The participant's environment may be unknown

*Strategy to overcome issue* - Ask participant about their surroundings

#### ii) Recording participant behaviour/interactions

*Potential problem* - Participant's behaviour or emotional state is unknown during the interaction with the experiment. They may have been looking and concentrating on a particular screen for 5 minutes or they may have left the computer for a few minutes.

*Strategy to overcome issue* - The only realistic solution is to use a webcam to capture the facial expressions and also to ensure the participant is present.

However, this does then lead to a loss of anonymity.

### **Technical issues**

#### i) Technical problems encountered

*Potential problem* - The computer may be running slow or their Internet connection may not be very fast.

*Strategy to overcome issue* - Ask participant if any technical difficulties were encountered.

#### ii) Participant computer experience

*Potential problem* - The participant may be unfamiliar with using a computer and this may make them feel anxious.

*Strategy to overcome issue* - Ask participant questions about their computer skills

### **Question design**

#### i) Question wording

*Potential problem* - The use of components such as drop-down boxes may force a participant's answer.

*Strategy to overcome issue* - Ensure that all questions have an 'opt out' answer that can be selected and the question design in general is rigorous.

ii) Interface design

*Potential problem* - Unintentional coercing of the participant by the use of affective wording or interface design; it has been shown that people respond to computers as social actors.

*Strategy to overcome issue* - Using a faceless, featureless interface may produce better results than a friendly computer generated face.

**Experimental protocol maintained**

i) Experimental flow

*Potential problem* – The participant may self-navigate through the experiment or question set inappropriately.

*Strategy to overcome issue* - Set the level of participant control so they can return to previous questions or not. The use of an applet can remove browser control.

ii) Participant individuality

*Potential problem* – It is unknown if the participant is alone or in company.

*Strategy to overcome issue* - Ask how many people are present, highlight that this is to be an individual task.

iii) Participant honesty

*Potential problem* – It is unknown if the participant is trying to be deceptive or hone their answers.

*Strategy to overcome issue* - Repeat questions throughout the test and compare the results as deceptive respondents may change their responses.



iv) Participant uniqueness

*Potential problem* – It is unknown if the participant has taken the test before.

*Strategy to overcome issue* - Capture the IP addresses to ensure uniqueness.

Complete avoidance of multiple data from a single individual is difficult (Nosek et al. 2002). For example, there may be several unique individuals who are using the same computer. Another alternative is to have a login process, but then anonymity may be lost if personal data is used for the login.

### **Conclusion of online research issues**

There will always be debate as to the validity of any research carried out online, just as there are still issues of validity with research carried out in a traditional face-to-face manner. Perhaps one could argue that there will never be a completely sound experimental design as there are ‘normally’ at least some variables that are outwith the researcher’s control. However, what have been introduced here are ways of minimising the potential problems of online research.

Kraut et al. (2004) summarised what they believed to be the value of various interaction techniques and how each method of interaction influences the ability to protect the research participants. They indicated that electronic forms signed by clicking to accept was the best method overall, with the only negative point being the lack of documentation of the consent form. However, this method provided more protection for the participant in other areas, such as participant anonymity and prevention of coercion. Lastly, whilst not knowing where a participant is or what their surroundings are can be considered a problem, this may not necessarily be the case. For example, a participant’s circumstances might be unknown, e.g., the participant may be in a room with the radio

on in the background, or perhaps in a busy public place with considerable background noise while completing the test, and this could be considered a disadvantage of the online environment. However, one could also argue that this is an advantage because the participant is experiencing the test situation in their 'natural' surroundings and so may feel more at ease as they are not in a test environment or being observed. This could also mean the participant is more likely to respond truthfully (Waterson & Duffy, 1984), perhaps due to a perceived sense of privacy (Kam & Chismar, 2003).

Having considered these issues of testing in an online environment it was decided that this would still be the most appropriate environment to conduct the experiments, since the benefits of using an online environment outweighed the problems. Particular benefits included the potential to recruit many participants, the anonymity provided by an online environment and the high level of availability of the test for the participants, i.e., the participant being able to access the test at any time.

### **3.3 Pilot study into the effects of music and animation in an e-learning environment**

A pilot study was created which incorporated music and animation into a PowerPoint presentation. This study had two aims: firstly, to establish the feasibility of using music and animation in an e-learning presentation and secondly, to evaluate the most appropriate use of music, e.g., if the music should play all the way through the presentation or only on some slides.

### **The pilot study design**

The pilot study design incorporated a PowerPoint presentation prepared as part of an online course that taught java programming to various groups, such as school pupils, college students and University staff, was utilised. The presentation content was not altered, but music was incorporated and PowerPoint animations were choreographed to the music. In this case ‘animations’ refers to the movement and enhancement of screen elements as opposed to the animation of cartoon style characters.

The PowerPoint presentation used was delivered in unit four of a six unit course. By the time students had reached the fourth unit it was expected that they would be familiar with the online environment and the style of the presentations, which were more interactive than most presentations delivered in a lecture theatre environment. It was important that students had become familiar with this presentation style so any questions would be related to the addition of the music and choreographed animations rather than the basic presentation style.

The researcher selected the music to be used in the presentation, choosing pieces of music that were upbeat and energetic as it was thought this had the potential to create a positive effect in the listener. The music was selected from production music provider Audiolicence.net and appropriate licences for using and playing the music were obtained.

Several prototypes were developed and evaluated to ascertain the most appropriate length of the music sections. Having the music playing for long periods of time or even

through the whole presentation was unanimously rejected by the participants during informal evaluations, with the final design consisting of three pieces of music, one piece over three consecutive slides lasting approximately 90 seconds and the other two pieces on individual slides each lasting approximately 30 seconds. Slides with the music and animation were interspersed throughout the presentation, which consisted of 32 slides in total. After watching the presentation the participants were asked some questions about the presentation (Appendix A).

### **The participants**

Ten participants were recruited from the Java Online course. This student group was made up of people who were computer enthusiasts wanting to learn about computer programming. The minimum age for students on this course was 16 years. For the purposes of this research any students with a visual or hearing impairment were excluded.

### **Ethical approval**

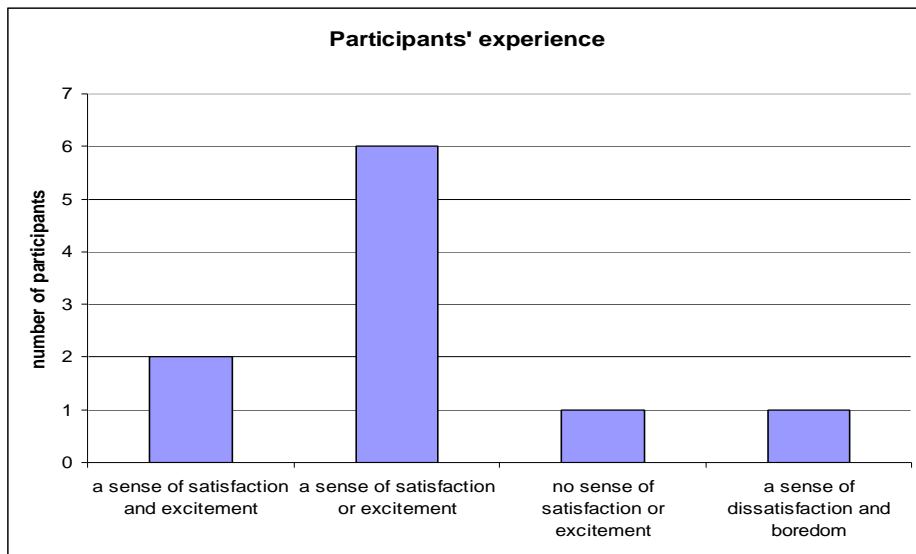
Ethical approval for this study was obtained in accordance with the guidelines from the University of Dundee, College of Art, Science and Engineering. It was made clear to the participants that their data was stored anonymously and that they could leave the study at any time without any undue consequences. All participants were required to indicate that they had read and understood the terms as laid out in the informed consent form before continuing with the test. This was carried out within the first slide of the presentation. The online ethical approval forms can be seen in Appendix B.

**Pilot study methodology**

The test was delivered in the same manner as all of the other course presentations, i.e., online. The majority of participants undertook the test in a remote location. However, two participants carried out the test in the computer laboratories within the School of Computing at the University of Dundee, where the researcher was able to observe them as they watched the presentation. The researcher was situated discretely in the lab so as not to disturb the participants or make them feel as though they were being watched.

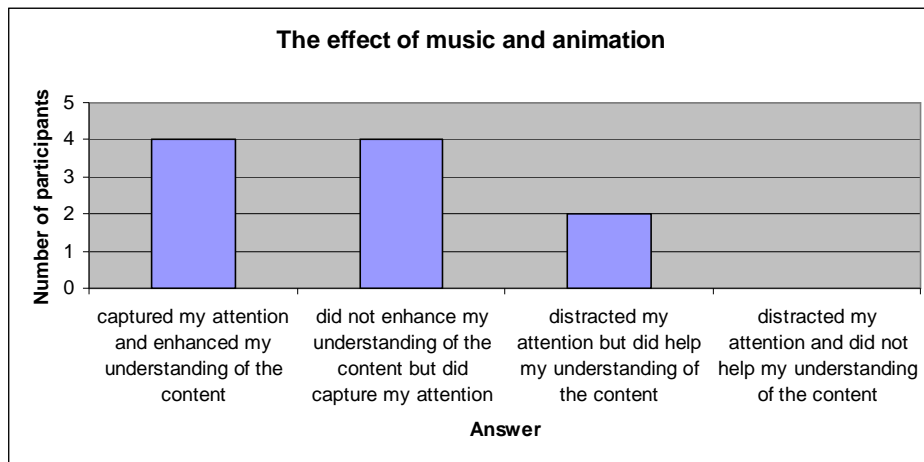
**Pilot study results**

A total of 10 Java Online students participated in, and completed, the test. The results showed that all participants either agreed or strongly agreed that they liked the way the PowerPoint slides were presented. All but two felt that the presentation made them feel alert some or all of the time. Nine of the participants felt that the way in which the content was presented helped them to concentrate, with six of these nine people experiencing happiness at times and the other three being indifferent. Figure 3.1 illustrates that two of the ten experienced a sense of satisfaction and excitement, while six of the ten experienced a sense of satisfaction or excitement. The remaining two experienced no sense of satisfaction or excitement, and one person experienced a sense of dissatisfaction and boredom.



**Figure 3.1 Participants' sense of satisfaction and excitement while watching the presentation (n=10)**

When asked about the effect the music had upon their attention and understanding, all the participants expressed some type of positive effect, as shown in Figure 3.2.



**Figure 3.2 Effects of the music and animation upon participants' level of attention and understanding of the content (n=10)**

When asked if they would like to have more presentations delivered in this way, eight agreed that they would, while the remaining two were indifferent.

The participants were invited to add additional comments for each question in order to gain more in-depth feedback. The majority of the comments were very positive about the inclusion of music and animation. In particular, one comment given repeatedly was that participants liked the way the animations were synchronised with the music.

Additional data was collected by the researcher when observing the two of the participants working through the presentation. The participants were seen to be smiling when the musical intervention slides were showing on screen, more so than during the rest of the presentation, and in particular laughing out loud during one of the musical interventions.

### **Conclusions from the pilot study**

The results from this pilot study showed an overall positive liking for the way in which the presentation was delivered, and also indicated that participants perceived it to have a positive effect upon their attention and understanding. Of course with such a small number of participants and the situation of the presentation being part of their course, there is a danger of the Hawthorn effect influencing the results (Clark 1999). However, during observation of the participants watching the presentation it was noticed that they were seen to be laughing at times when the music and animation were playing. Since there were no other obvious signs of an emotional trigger for this laughter it was fair to assume that it was the presentation that caused the laughter. This suggests that the use of music and animation can educe a positive affect upon the participants. Furthermore, the

results showed that a study of this nature would be feasible, with overall findings indicating that further study in this area would be of value.

### **3.4 Summary**

This chapter has described some of the potential problems often encountered when running experiments in an online environment, and discussed ways of minimising these problems. A pilot study into the use of music and animation in an e-learning setting was also detailed. The music in this pilot study was selected by the researcher based upon their own preferences and ideas as to the type of music most appropriate. Chapter 4 describes a study that was carried out to enable a more rigorous scientific approach to the selection of music for use in the study.



## **CHAPTER 4**

### **THE MUSIC SELECTION EXPERIMENT**

Chapter 3 described a pilot study to investigate the feasibility of an experiment to identify the effects of music and animation upon the e-learner. In order to progress this pilot study to a larger scale and a more scientifically rigorous experiment it was necessary to select music excerpts for use in the music and animation study. In the pilot study, music was selected by the researcher, and while the music appeared to be appropriate there was no clarification of the general effects the music had upon the participants' emotional states. Hence there was a need to develop a method for selecting pieces of music that could be shown to enhance positive emotions within the listener. This was because, as discussed in chapter 2, negative emotional states are generally not thought to be conducive to learning or to entering into an optimal learning state (Chaffar & Frasson, 2004), with emotions such as sadness shown to decrease prospective memory (Kliegel et al., 2005).

#### **4.1 Experiment Aims**

The aim of this study was to identify music that provoked positive and arousing feelings in people listening to music in an online environment. To achieve this, two experiments were devised; the first was a three-part experiment that would:

(i) identify whether the emotions that listeners perceived the music to be expressing were the same/similar to those actually experienced while listening to the music (emotions evoked and expressed). This was because it was important to identify

whether the emotions the listeners believed the music to be expressing were the same or similar to the emotions experienced by the user, as this could affect music selection. For example, if a listener perceived a piece of music to be expressing happiness but it made them experience sadness, this would not be a suitable piece of music to use to create a positive emotional state in the listener.

(ii) identify if and how a listener's emotions changed over time (emotional variation).

This was necessary because even if it was assumed that music could evoke emotional reactions in listeners, it was still unclear whether that emotional reaction would have a lasting effect, or if and how it might change over a period of time. Given the need to select music which produced a positive emotional response in listeners over a period of approximately 30 seconds (the estimated average time per slide), it was essential to measure any significant fluctuations in the emotions of the listener over that period of time.

(iii) collect general data about the listener (general data). Several factors can affect the emotional responses of a listener, such as age, gender, cultural background, familiarity with a piece of music (Ritossa & Rickard, 2004), and also their musical taste (Kreutz, Ott, Teichmann, Osawa & Vaitl, 2008). Hence it was necessary to collect data about the listeners and their music listening habits.

Since the results from the first experiment indicated that the emotions expressed were generally the same or very similar to those being experienced while listening to the music, the second experiment only identified the emotions evoked by music. The second experiment also collected further general data about the listeners but did not

measure the variation of the emotions over time as this was found to be negligible in the first experiment.

## **4.2 Measurement methods**

Having identified the need to elicit a participant's emotions while they were listening to music, several methods of recording the listener's emotions were considered, including using physiological measurements, questionnaires and focus groups. The main methods considered are detailed below.

*Physiological measures:* Studies have highlighted the potential benefits of using physiological measures as a means of eliciting a person's emotional state (Kivikangas, 2006; Bamidis, Papadelis, Kourtidou-Papadeli, Pappas & Vivas, 2004; Wilson & Sasse, 2004), while others have made use of physiological measures as a method to elicit a person's emotional state as part of a wider study (Krumhansl, 1997). However, there are difficulties associated with physiological measures. For example, the person usually has to be 'wired up' to numerous machines in order to measure skin moisture, heartbeat, and other parameters. This in itself has the potential to cause the person some level of anxiety, with the result that what is usually referred to as a settling period is required to allow the person to return to a less anxious state, and this could take up to 10 minutes. If there are many subjects taking part in a study it can become a very time-consuming process. An additional demand upon resources is that the readings from the equipment require specialist analysis to interpret them.

*Questionnaires:* While a questionnaire can be easily written, careful wording of the questions is required to avoid misinterpretation or bias toward a specific answer. Questionnaires are commonly used and the format is easily understood by subjects. They can be filled out on paper or online, allowing tests to be run from numerous locations.

*Think aloud:* Similar to questionnaires, this method could be used to elicit both the emotions experienced and perceived by the subject. Participants are asked to describe what they are thinking and feeling as they carry out a particular task. This can be a very useful method of eliciting a person's feelings and thoughts; however, some subjects could find it very distracting to talk about what they are feeling whilst carrying out another task. An observer could be present, or alternatively the subject could be recorded while the task was being carried out so that their verbalised thoughts and behaviour could be examined at a later date. It should be noted that having an observer or being recorded could make the subject feel uneasy, and this could affect the results.

*Observation:* Direct observation of the subject, i.e., watching their expressions and body language, would be a very limited method of detecting a subject's emotions. In some cases it might work well, for example if a person smiled then you could identify that they were happy. However, it would be possible for a subject to 'force' a smile when in fact they might feel sad. Similar to "think aloud", some subjects could feel uneasy having someone watching them or being recorded. In addition this method would only detect the strong emotions felt by subjects and not reveal how subjects perceived emotions.

*Focus group:* A focus group could allow a deeper exploration of the emotions being felt and perceived by the subjects, although discussion amongst the group could lead to a dilution of an individual's emotions. This method would be well suited where the elicitation of a community's general emotions was required, but it would not be so well suited for examining the personal feelings of an individual.

Having reviewed the above methods, the physiological, observation and focus group methods were discarded for the following reasons:

*Physiological* – The amount of time required per subject would make this method prohibitive when collecting data from large numbers of participants. There would also be a need for specialist equipment and specialist analysis of the results obtained.

*Observation* – This method would only detect emotions experienced by the subject that are strong enough to show in their body language. There would also be the need for an expert to analyse and interpret the subject's body language.

*Focus group* – The subject's emotions could be influenced by peer pressure; the subject's true emotions experienced or perceived might not be elicited.

Both think aloud and questionnaires were considered further. The questionnaire method was considered to be more effective than the think aloud method. This was because the think aloud method would still require an observer, and as discussed this could unsettle the subject, and the subject might also find it difficult to put into words the emotions they felt or perceived. Additionally, the think aloud process could distract the

participant from the main task of listening to the music. By using questionnaires for this study it would be possible to elicit the emotions subjects are experiencing, as well as the emotions they perceive. However, it should be noted that very subtle emotions may be missed by the user, and so while they may experience them, it is likely that only the most dominant emotions will be the ones they notice.

Having decided that a questionnaire style would be employed, various methods of emotional association were explored:

*Word association:* A segment of music would be played and the subject asked to select a word from a list that best described a) the emotion they felt, and b) the emotion they thought the music was conveying. This method would elicit both the experienced emotion and the perceived emotion. However, the words in the list would have to be carefully selected and categorised prior to the test. The list of words could prove to be limiting if the subject felt that there was not an appropriate word available, and they might be forced to select another unless there was a free-text option available. However, this would make it difficult to categorise.

*Film/animation association:* Play a piece of music and have the listener select a film segment portraying the appropriate emotion. Although this idea would be along similar lines to the word association, it could prove to be fraught with problems. The film segment could be open to several interpretations and could be difficult to categorise, unlike words that (if carefully selected) would not be open to interpretation (e.g., the word “happy” only really has one meaning).

*Image association:* Play a piece of music and have the listener select an image that they felt portrayed the appropriate emotion. If the images were not open to multiple interpretations, this method could prove useful.

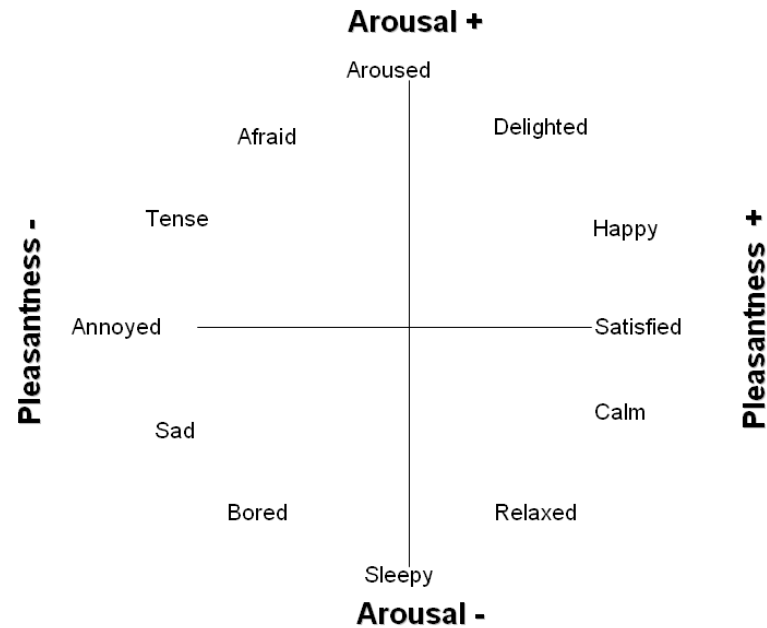
A word-association method of questionnaire was employed as this would allow the emotions to be clearly categorised. However, as with all of these association methods, word-association would require one static axis and one dynamic axis. In other words the music would be the dynamic axis, as each piece of music would be conveying a slightly different emotional content, and the associated word (image or film) would need to have a 'fixed' meaning that was understood by all subjects. Without this framework the results would be impossible to interpret. For example one subject could select an image to represent a happy emotion, whilst another subject could select the same image to represent a sad emotion. For this reason it was necessary to identify words that would represent the same meaning for each of the participants. It was considered that words would be less open to misinterpretation than images would be. The next section looks at how these emotionally-rated words were selected.

### **4.3 Emotional rating**

According to Landry (2004) there is a difference between an emotion, a feeling and mood, as described in chapter 2. For the purposes of this research the definition of an emotion will be a feeling that is caused by an external stimulus. This follows Landry's description of an emotion and since a user's interaction with the computer interface would be considered as an external stimulus it could be assumed that the person's emotions can be influenced by this external stimulus.

As these experiments aimed to identify a listener's emotions it was important to offer the participant a wide range of emotions to select from, i.e., both positive and negative. The circumplex model of emotions put forward by Russell (1980) presented a framework which was compatible with the needs of this research, allowing a range of emotions to fall into one of four quadrants along the axis of arousal and pleasantness. A list of twelve emotions were selected according to their position within Russell's circumplex model of emotions (Russell 1980). For example 'tense' would show negative pleasantness and positive arousal. The 12 emotions selected were: aroused, delighted, happy, satisfied, calm, relaxed, sleepy, bored, sad, annoyed, tense and afraid. These emotions were then verified against the Affective Norms for English Words (ANEW) a set of over one thousand words that have been rated along the affective dimensions of dominance, pleasure and arousal (Bradley & Lang, 1999b). These words have been specifically rated in order to provide a standard for words to be used in studies such as this one, in terms of emotion and attention. This verification was carried out to ensure that the twelve emotions provided a range of emotions along the axes of pleasantness and arousal. Whereas the circumplex emotional space does not place each emotion on the axis according to an exact scale, it would be possible to plot exact positions of the emotions using the ANEW ratings. The word *calm* did not appear in the ANEW list, but a similar word *soothe* was selected instead. Also the words, *sleepy* and *annoyed* were substituted in the ANEW with *sleep* and *annoy* respectively as there were no ANEW ratings for these exact words. Appendix C provides the exact ANEW mappings. The positions of the list of words selected can be seen in Figure 4.1. The comparison of the two emotional ratings provided validation that the emotions selected for this experiment provided a range of negative and positive emotions along the axis of arousal and pleasantness for the participant to select.





**Figure 4.1 The emotional space: An adaptation of the circumplex model of emotions by Russell (1980)**

#### **4.4 Music experiment 1 – Design**

Experiment 1 was designed to obtain information about each of the three issues identified previously: ‘general data’, ‘emotions evoked and expressed’ and ‘emotional variation’

- (i) General data – This part of the test obtained general information about participants, such as age and gender, as well as their music listening habits, e.g. their reasons for listening to music while working online. This would be important data to obtain as it would enable differences such as gender to be analysed.

- (ii) Emotions evoked and expressed – The second part of experiment 1 involved several different pieces of music being played, with listeners being asked to identify the emotions they perceived to be expressed by the music, as well as the emotions they experienced whilst listening. The aim of this would be to enable a comparison between the perceived emotions being expressed by the music and the emotions experienced.
- (iii) Emotional variation – for the final part of this experiment music segments lasting 30 seconds would be played to identify the temporal stability of the listener's emotions.

#### **4.5 Music experiment 1 – Methodology**

##### **Music experiment 1 (i) - General data**

This was the first section of the online experiment that the participants were presented with. It consisted of the question set which was a mixture of check boxes and radio buttons to select the answers from. Where there was a list of items to select from, e.g. what type of music they liked listening to, there was also an option for 'other' and a text box for them to enter an alternative style. (Appendix D provides the full set of questions).

##### **Music experiment 1 (ii) - Emotions evoked and expressed**

In this section of the experiment 8 different pieces of music were played to the participant and after each had played the participant was asked to select the emotions

they perceived to be expressed by the music, and the emotions they experienced whilst listening to the music. To achieve this, the participants were asked to select the emotions from two identical lists: one list representing the emotions they felt the music was expressing and the other to represent the emotions they were experiencing. Eight music excerpts were played for approximately 30 seconds. Figure 4.2 shows a screen shot of this section showing how the listener would select from the list of emotions. An option was also provided for no emotion.

Below are two lists of emotions. once the music begins playing please select the emotions you are experiencing and the emotions you feel the music is expressing by clicking the check boxes from the appropriate list.

You may select more than one emotion if you wish.

Once you are ready to hear each piece of music click the button 'Begin next piece of Music'.

**Begin next piece of music**

<b>Emotions you are experiencing</b>	<b>Emotions you think the music is expressing</b>
<input type="checkbox"/> Aroused	<input type="checkbox"/> Aroused
<input type="checkbox"/> Happy	<input type="checkbox"/> Happy
<input type="checkbox"/> Calm	<input type="checkbox"/> Calm
<input type="checkbox"/> Sleepy	<input type="checkbox"/> Sleepy
<input type="checkbox"/> Sad	<input type="checkbox"/> Sad
<input type="checkbox"/> Tense	<input type="checkbox"/> Tense
<input type="checkbox"/> No emotion	<input type="checkbox"/> No emotion
<input type="checkbox"/> Delighted	<input type="checkbox"/> Delighted
<input type="checkbox"/> satisfied	<input type="checkbox"/> satisfied
<input type="checkbox"/> Relaxed	<input type="checkbox"/> Relaxed
<input type="checkbox"/> Bored	<input type="checkbox"/> Bored
<input type="checkbox"/> Annoyed	<input type="checkbox"/> Annoyed
<input type="checkbox"/> Afraid	<input type="checkbox"/> Afraid

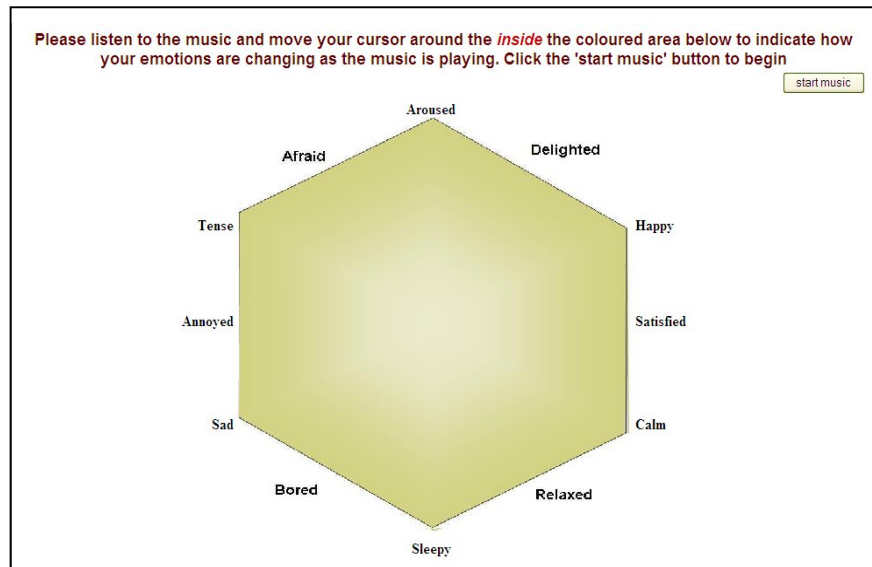
**Figure 4.2 Screen shot for Experiment 1 (ii) – Emotions evoked and expressed**

The list of emotions was provided to each participant in the same order. Although this could be considered to provide a bias for participants to select the same emotions each time, it was felt that due to the increased cognitive load on the participant there may be a negative effect if participants were asked to listen to music and then read through a changing list of emotions before making their selection. Excerpts of music were played in a random order to remove any influencing factor of one piece of music being followed by another.

### Music experiment 1 (iii) - Emotional variation

In this section of the experiment, participants were played four pieces of music each lasting for 30 seconds and were asked to move their mouse inside a coloured hexagon to indicate how they were feeling at any given time. Mouse location was recorded every two seconds and a value for pleasantness and arousal assigned according to the mouse location.

The emotions given around the perimeter of the coloured area shown in Figure 4.3 relate to emotional space (Figure 4.1).



**Figure 4.3. Experiment 1 (iii) – How participants could select their emotional variation**

### Music selection

It was important that the music should be unfamiliar to listeners, as a familiar piece could produce an associated emotional response (Millbower, 2003; McClelland & Chappell, 1998). For example while a piece of music may be deemed as happy, a

listener may have a memory of the music playing while experiencing a negative event. Thus, when hearing this music again they might experience a negative emotion due to the association. Other factors such as cultural background and the possible emotional influence of lyrics were also considered and, in a similar manner to other studies such as that by Laurier & Herrera (2007), the solution to these potential problems was to use excerpts of unknown western instrumental music.

A selection of music was chosen to cover various styles, such as classical, big band, hip hop and funk. The majority of this music was provided by Audio Network<sup>2</sup>, a music production company that holds a large collection of music for production purposes. The remaining music used was sourced from Magnatune<sup>3</sup> and other similar royalty-free sources. Music was selected from these sources rather than using ‘popular’ music that is in the charts or well-known pieces of music to reduce the possibility of participants being familiar with the music.

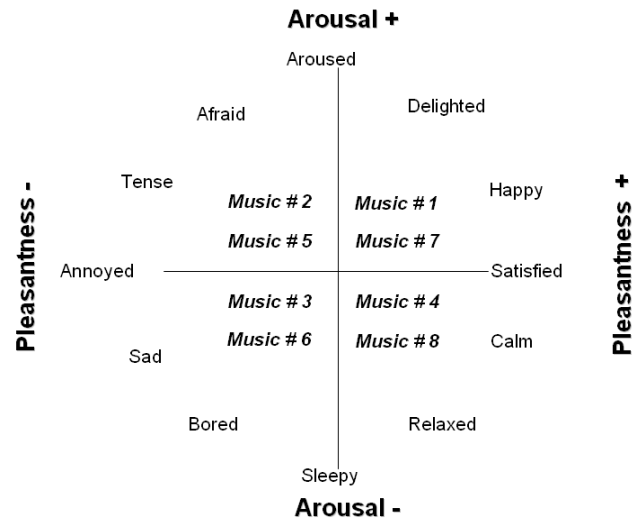
### **Emotional rating of music samples**

Music excerpts were chosen to cover the full range of emotions (both positive and negative) of pleasantness and arousal. Two pieces of music would represent each of the quadrants as shown in Figure 4.4. This selection was based upon the description that Audio Network and Magnatune had provided for each piece of music and the category they had placed the music in, along with the researcher’s opinion of the music.

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<sup>2</sup> Audio Network accessible at <http://www.audionetworkplc.com/>

<sup>3</sup> <http://www.magnatune.com/>



**Figure 4.4 The position of the music within the emotional space**

### Technical aspects of the design

Since the music would be used in an online environment it was judged that the most appropriate test environment for music evaluation would also be online. This was to guard against the possibility that the emotional responses of listeners might be different depending on how the music was delivered, e.g., music delivered online might evoke a different response to music played on a CD player, or live music played in a concert hall.

The test was written using the HTML programming language, with music files embedded in Adobe Flash and JavaScript as this provided the best means of cross-platform support. This was important as it would allow participants in remote locations using different computers with various operating systems and web browsers to access the experiment. PHP files that were connected to a MySQL database were used to capture the data generated by the test.

## **Participants**

A total of ten participants took part in the test. These participants were members of staff, postgraduate and undergraduate students from the School of Computing at the University of Dundee who were invited by email to participate in the test. This group of participants were invited as they represented a group with varying characteristics such as age and gender. They were also a group of people who were likely to be studying or working in an online environment since they were from the School of Computing.

## **Ethical approval**

Ethical approval for this study was obtained in accordance with the guidelines from the College of Art, Science and Engineering, University of Dundee. It was made clear to the participants that their data was stored anonymously and they could leave the study at any time without any undue consequences. All participants were required to indicate that they had read and understood the terms as laid out in the informed consent form before continuing with the test.

## **4.6 Music experiment 1 - Results**

### **(i) General questions – results**

The results from the general questions showed that from the styles of music that the participants indicated that they either liked, or listened to while working (they were able to select several styles of music) that in 11 of the 17 instances the music the participants

liked and the music they listened to while working were the same. Seven of ten participants stated they listened to music while working because they enjoyed the music, while the remaining three listened to music as it helped them to concentrate. Three participants listened to music while working solely at home, and three participants listened to music while working solely in a public place. A further three listened in both locations.

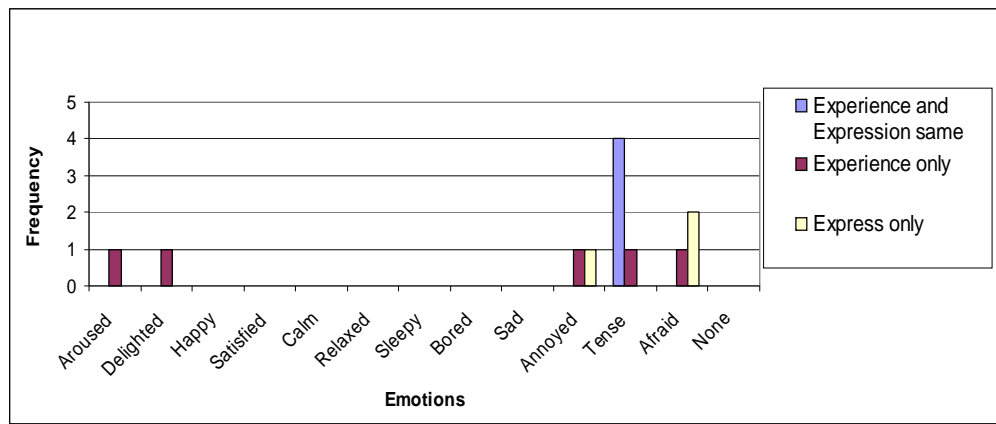
The most interesting finding from this set of questions was the high proportion of people who listened to music while working, with nine of the ten people listening to music while working either occasionally, often or all the time.

## **(ii) Emotions evoked and expressed– results**

Results indicated that the majority of emotions expressed and experienced were the same, with 63% of the 165 emotions selected creating exact matched pairs, i.e., the emotion selected for “expresses” was the same as the emotion selected for “experienced”. There was an odd number of emotions selected since there were occasions where participants selected no emotions or the list of emotions was left blank.

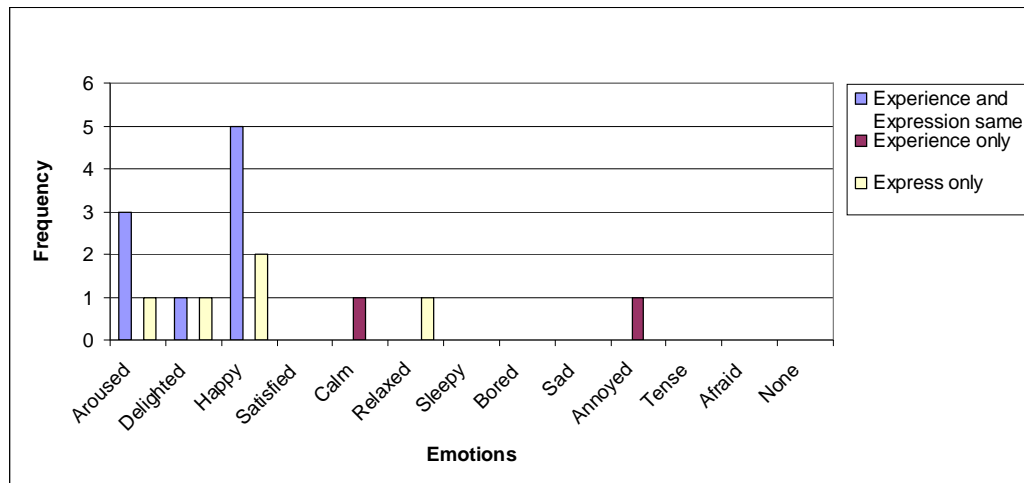
The results showed that music could be categorised within the emotional space. Figure 4.5 illustrates how ‘Music # 5’ evoked and expressed predominantly annoyed, tense and afraid emotions. When referring back to the emotional space it is clear that these emotions fall into the category of negative pleasantness and positive arousal. Conversely, Figure 4.6 shows how ‘Music # 1’ predominantly evoked and expressed aroused, delighted and happy emotions, and these reflect a positive state of arousal and pleasantness within the emotional space.





**Figure 4.5 Emotions of Music # 5**

*Note – ‘Experience and expression same’ represents two sets of data; experience and expression. They are shown together since they were reported as being identical.*



**Figure 4.6 Emotions of Music # 1**

*Note – ‘Experience and expression same’ represents two sets of data; experience and expression. They are shown together since they were reported as being identical.*

Although not every piece of music produced such clear groupings of emotions as the two shown above, these findings demonstrated that some pieces of music can clearly be categorised by both the emotions the listener experiences and the emotions they felt the music was expressing.

### **(iii) Emotional variation– results**

The results from the final part showed no significant change in the arousal or pleasantness levels in any of the pieces of music over the 30-second period that the music was playing for (see appendix E for the full set of results). Of course only four music excerpts were tested and there were only a small number of participants, and only seven participants completed this part of the test. However, these results do indicate that the emotional variation of the listener does not change very much over a short period of time.

## **4.7 Music experiment 2 - Design**

Following the completion of experiment 1, the test was redesigned and informal evaluations carried out with the new design. The decision was made not to measure the variation of emotions over time as the results from this part of experiment 1 showed no significant variation in the emotions experienced during the music sections, and it was therefore considered not to be relevant. The results from experiment one also showed that 63% of the emotions experienced and expressed were the same. These findings reflect similar views of other researchers, as discussed by Timmers, Marolt, Camurri & Volpe (2006). Thus it was decided to measure the emotions experienced only. The emotions experienced were to be reported rather than the emotions expressed as it was felt that where variations may occur between the emotions expressed and experienced it was the experienced emotions that would be of the most value to this research. Reducing the amount of data to be recorded was considered to be an improvement to the test as the cognitive load on the participant would be reduced by having fewer questions

to answer. This also allowed for a wider selection of music to be used, since there would be no need for the participant to report on the emotions expressed by the music or the variation of their emotions. In order to provide a wider selection of music, this part of the experiment was expanded to include three additional excerpts of music; this brought the total number of excerpts to 11 (see appendix F for details of music).

As with experiment 1, the order the emotions were displayed in the list would be constant, but the play order of music would continue to be randomised. The general questions would be asked at the end of the test rather than at the start in order to reduce the initial burden on participants.

Thus there would only be two main sections in experiment 2, the ‘emotions evoked’ and the ‘general data’.

### **Participants**

An invitation to participate in the test was posted on web forums for students throughout the UK. This group of participants were targeted as they represented a subset of what would be the major group of participants for the main experiment for this research. As these participants were invited via a web forum it meant that they were known to have access to an online environment in which to take part in the test.

#### 4.8 Music experiment 2 - Results

##### Music experiment 2 (i) General data– results

A total of 42 participants completed the whole test. Although 53 participants initially started the test, 11 of those did not fully complete it. Thirty-one participants were in the age group ‘up to 20’, while nine were aged 21 to 30 and two were aged 31 to 40.

The results for the general questions showed the majority of participants (92.9%) actually listened to music, or would have liked to be listening to music, while working at some time (Table 4.1).

**Table 4.1 How often people listen to music while working (n= 42)**

How often do you (or would like to) listen to music while you are working or studying?	Number
Most of the time	18
Often	11
Occasionally	10
Never	3

Over 50% of participants said their reason for listening to music was to help them to concentrate. Over 50% also chose to listen to music while working, because they enjoyed the music (Table 4.2).

**Table 4.2 The frequency of listening reason (n=42)**

Reason for listening to music whilst working	Number
To block out noise	14
Enjoy the music	25
To help with concentration	22

It was found that 25 participants listened to music while working at home only, while 14 participants listened to music both at home and in a public place, such as a computer lab whilst working.

Table 4.3 shows that the most commonly listened-to music was rock, followed by jazz and classical. If participants selected 'other' they were invited to give details of what style of music they liked and listened to, and a total of 15 different styles were identified. However, each different style was only indicated by one or two participants. The percentage of people who both liked and listened to this 'other' music while working was not calculated as there was no way of making this comparison given the wide range of different styles reported.

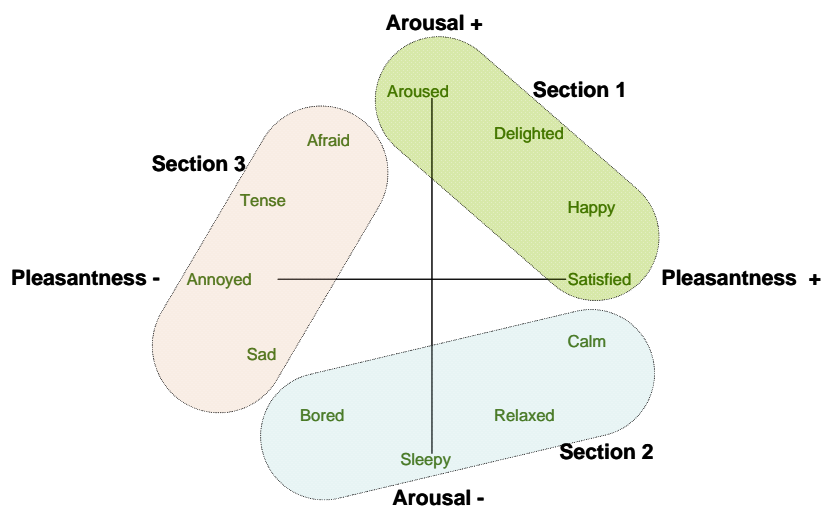
**Table 4.3 The frequency of music listening. (n=42)**

Type of music	Number of people who like this type of music	Number of people who listen to this type of music while working	% of people who like this type of music who also listen to it while working
Rock / Pop	35	27	71.1%
Jazz / Blues	21	10	47.6%
Classical	20	18	90.0%
Heavy metal / Punk rock	17	7	41.1%
New age	7	5	71.4%
Other	14	11	-

Findings showed that there were no significant differences identified between the age groups or between male and female participants with regards to the type of music they liked, the reasons for listening to music while working, or where they listened to music while working.

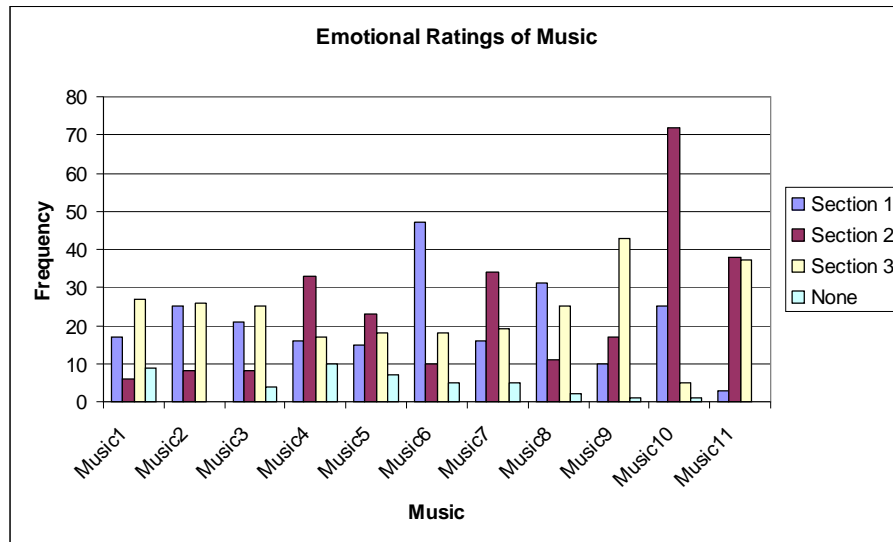
### Music experiment 2 (ii) results – Emotions evoked

The emotional space was divided into three distinct sections, as illustrated in Figure 4.7. This was done to allow all the emotions that represented a positive level on the axis of arousal and pleasantness, or positive on one axis and neutral on the other axis, to be categorised since the music that best fitted with these emotions would be the music that would be used in the main music and animation experiment of this research. The emotions of aroused, delighted, happy and satisfied were grouped together and represented section 1. Since section 1 included four emotions the other two sections also included four emotions and represented different levels of arousal and pleasantness. Section 2 included the emotions that mainly represented a low level of arousal, while section 3 represented the least pleasant emotions.



**Figure 4.7 Grouping of emotions within the emotional space**

As can be seen in Figure 4.8, ‘Music6’ induced the most experiences of emotions in the first section with 47 reports of a positive and arousing emotion being experienced, although it was amongst the lowest reports for the second and third sections, with 10 and 18 reports respectively.



**Figure 4.8 The emotional rating of the music sections**

‘Music10’ clearly produced the strongest results within the second section and ‘Music9’ within the third section. Interestingly ‘Music5’ produced almost equal results in each section of the emotional space, and ‘Music11’ showed results predominantly in the second and third sections.

#### **4.9 Limitations of the experiments**

As with most experiments there were potential problems with the experimental design. Factors that could have affected the results, but that were not controllable, included:

- Where participants were during the test
- What participants were doing or listening to prior to or during the test
- If the participants were alone or in company
- What the current trend in popular music was
- Familiarity with the music
- Technical difficulties encountered
- Participants' familiarity with an online environment

Additional to the above, although it was unlikely that participants had heard the music before, it could not be guaranteed. The only way to ensure the music had never been heard before would have been to have composed new pieces of music. However, the cost of this was prohibitive for this research.

#### **4.10 Discussion on the music selection**

The results for the music liked and listened to produced several interesting results. Firstly, given the age group of the participants it was no surprise that rock/pop music was the most listened to. However, a surprising result was that almost half of the participants also reported liking classical music. This is not a finding that one would expect to find given the relatively young age group, as the younger generation are often stereotyped as not liking classical music.

The second finding of note is the high percentage of participants that both listened to and liked classical and rock/pop, although less than half of those who said they liked jazz and metal/punk rock listened to this style of music while working. This indicated there might be something about these types of music that would cause people not to



listen to it while working. Perhaps this was due to the lack of structure in jazz music that caused it to become distracting to listeners when they had to be focused upon other things. Conversely, classical music is more structured in nature and may be easier to work to. Day, Lin, Huang & Chuang (2009) showed that tempo can have an influence upon task difficulty and multi-attribute decision-making, thus it is not unreasonable to assume that tempo may also affect a person's ability to concentrate upon work.

Of course there is always the possibility that although many people like and listen to rock/pop music whilst working online, this type of music may be detrimental to their state of mind for work. However, there is also the possibility that listening to jazz whilst working online could enhance the working potential of the listener. Further research would be required in this area to begin to provide answers to these questions. Given the high proportion of people listening to music while working in online environments, finding answers to these questions is important.

The method of music selection was discussed by Grice and Hughes (2008) and the styles of music presented and the music selection processes from other domains were considered. For example if music for a film were to be selected by the audience in this manner one may wonder if it would still have the same impact, or convey the appropriate message when embedded into the movie as when the music was selected by the producer.

#### **4.11 Conclusions**

The purpose of this preliminary study was to identify music that produced a positive emotional experience in the listener that could then be used in the music and animation

study. Results from experiment 2 identified two pieces of music which fitted these criteria. Additionally the results from the experiments carried out clearly showed that while not every piece of music could be emotionally categorised using this method, there was scope for it to successfully categorise some pieces of music. A similar methodology has been successfully used by other researchers such as Laurier and Herrera (2007) and may prove to be a useful methodology for future researchers.

The results from this study offer support for the concept that music can both express emotional content and cause an emotional reaction in the listener. The emotional variation seen over the 30-second excerpts of music varied between each piece. One could assume that some pieces will express much variation over the 30 seconds while others will show little change.

This study highlighted the high proportion of people who listen to different styles of music while working online. One of the main reasons for listening to music while working was to help with concentration. Furthermore they were listening to different styles of music like rock and pop, and not only classical music, which most of the limited number of studies in this area have focused upon. This is despite the recognition that many young people prefer other styles of music such as rock and pop (Barone, 2006; Williams, 2001; North, Hargreaves & O'Neill, 2000). Hence there is a need for further research to be conducted to establish if, why and how particular styles of music can enhance peoples' productivity when working online, improve their concentration, or even enhance their learning ability within an online environment.

## **CHAPTER 5**

### **INTRODUCTION TO FLOW**

The previous chapter identified excerpts of music for use in the music and animation study by categorising them using emotionally-rated words. To further develop this study, a more detailed framework of emotional states was required. This chapter builds upon the discussion of emotions in chapter 2 and explores various emotional models and looks at how emotions can affect people's behaviours and perceptions. A review of literature on the uses of flow within online environments is described and finally ways of measuring flow are explored.

#### **5.1 Emotional models**

The use of emotional models allows us to conceptualise the emotional process that people go through during a task. For example, Kort et al. (2001) developed an emotional model with two aims in mind: firstly to enable the effects of emotions upon learning to be evaluated, and secondly to enable the recognition of a learner's emotions by a computer, which could then allow the learner's emotional state to be effected specifically for learning at an optimal pace. They proposed a model based upon two axes - that of affect (positive or negative) and learning (constructive or unconstructive). They proposed that a student may move around the four quadrants of the model during the learning process.

Other models exist, such as the theory of planned behaviour. This is an extension of the theory of reasoned action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and is based around the concept that a person's behaviour can be predicted (to a degree) by their personality traits and attitudes. Vuorela and Nummenmaa's (2004) research aimed

to evaluate whether the theory of planned behaviour could explain a participant's activities within e-learning environments. Their findings did not support the theory of planned behaviour.

Another model which also aims to predict the actions, or at least the intentions, of a person is the Belief- Desire-Intention (BDI) model. This model of human practical reasoning provides a means of predicting future-directed intentions of a person. Jaques and Vicari (2007) used the BDI model in their study to enable them to infer a learner's emotions from their actions. They found the BDI model to be adequate to infer the learner's affective states. The BDI model is also the basis for the BDI software model, which has been used for the programming of intelligent agents (Go & Lee, 2007; Georgeff, Pell, Pollack, Tambe & Wooldridge, 2000). The Expectancy Disconfirmation Theory (EDT) is one that is used extensively in market research, not to predict human emotions, but rather to allow the level of satisfaction or dissatisfaction towards the service or product to be measured.

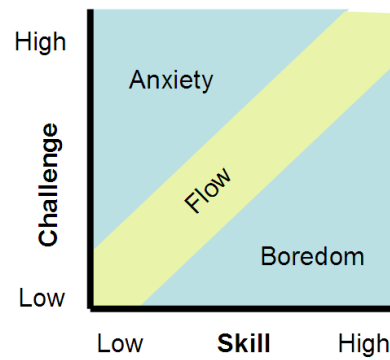
This theory uses the consumer's pre-consumption expectations and compares them with post-consumption experiences to identify a level of satisfaction. The theory has also been used for measuring students' attitudes towards e-learning. For example Chiu et al. (2005) used the EDT to measure the perceived usability, quality and value of e-learning. Their results indicated that satisfaction, which is jointly determined by perceived usability, perceived quality, perceived value and usability disconfirmation, was an indicator in a student's continuance intention towards the e-learning.

The flow theory provides another way of modelling behaviour. This is described in more detail in the next section as it was a model that was used in the rest of this research.

## 5.2 What is flow?

As early as 1975 Csikszentmihalyi described the term ‘flow’. It can be compared with the term ‘in the zone’ which is often used by athletes and sports people. An accepted definition of flow or being ‘in the zone’ is still to be determined as there are several ways of describing it. For example: Csikszentmihalyi and Moneta (1996, p.277 in Chen, 2006b) state “*Flow is the psychological state in which an individual feels cognitively efficient, motivated, and happy*” , while Csikszentmihalyi also describes flow as being “*The state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it*” (Csikszentmihalyi, 1991, p.4) and the “*holistic sensation that people feel when they act with total involvement*” (Csikszentmihalyi, 1975, p.36). Despite the lack of a simple definition there appears to be little dispute in the academic world that flow is a very real experience and that it seems to have an effect on the people who experience it (Chen 2006b; Pearce, Ainley & Howard 2005; Pace 2004; Skadberg and Kimmel 2004).

In its most basic form flow can be mapped as shown in Figure 5.1, where if a person has a low skill level for a task that they find challenging then they are likely to experience anxiety. Conversely if they have a high degree of skill and the task posed is not very challenging to them then they are likely to become bored. A flow experience is most likely to occur when the skills required are matched by the level of challenge, thus maintaining an interest in the task without it becoming too difficult. In this model there are three distinct channels that a person can experience; anxiety, flow or boredom.



**Fig. 5.1. The three-channel model of flow**

The level of skill and challenge are not the only factors affecting a person's flow experience. Other influencing factors can include:

- Clear goals.
- Immediate feedback.
- Action and awareness merging.
- Concentration on the task.
- Sense of control.
- Loss of self-consciousness.
- Altered sense of time.

Since 1975, models of flow have evolved although the essence of what flow is has remained constant. One of the earliest models of flow described by Csikszentmihalyi (1996) identified just four components: control, attention, curiosity and intrinsic interest. However, as the list above shows several more components have since been suggested.

It is generally accepted that while presenting a person with all the components of flow will not guarantee that the person will enter a state of flow, it will greatly increase the possibility of them entering such a state. This is thought to be due, in part, to individual

differences in character (Shin, 2006; Finneran & Zhang, 2005), but could also be due to the task being undertaken (Finneran & Zhang, 2003; Finneran & Zhang, 2002). Some researchers have included additional components such as telepresence - a term used to describe the experience of presence in an environment by means of communication - and autotelic, which describes the situation when a task is completed because the task itself is the motivation for completion rather than some external motivating factor. For example Chen (2000 in Finneran & Zhang, 2003) attempted to empirically validate the structure of flow, identifying 3 distinct stages:

**Antecedents of flow:**

- Clear goals
- Immediate feedback
- Potential control
- Merger of action and awareness

**Flow experience:**

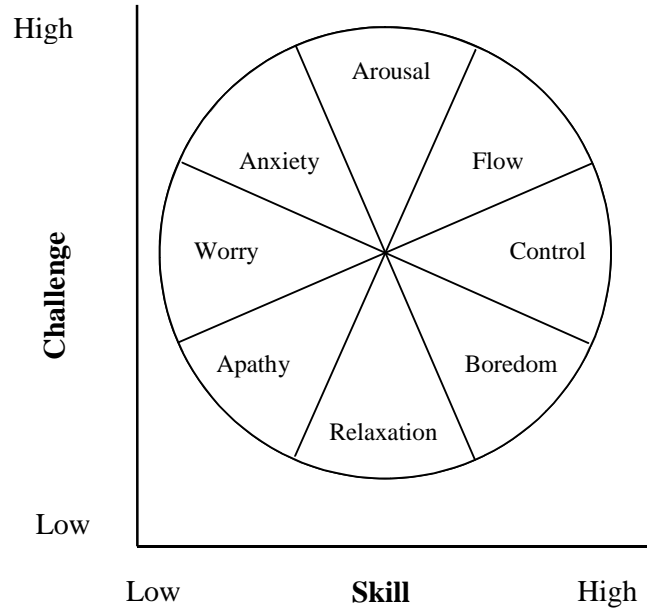
- Concentration
- Loss of self-consciousness
- Time distortion
- Telepresence

**Consequences of flow:**

- Positive affect
- Autotelic experience

Not only have more components of flow been added to the model over the years, but the number of channels within the flow model have also been increased. Figure 5.2 shows a representation of the eight-channel model of flow as described by Pearce et al. (2005). As in the original model in Figure 5.1, the eight-channel model presents emotions according to the level of skill and challenge experienced by the person; however, in the model in Figure 5.2 there is a finer-grained differentiation between the levels of skill

and challenge, enabling the categorisation of eight emotions instead of just two. These models again demonstrate the evolution of the understanding of flow over the years.



**Figure 5.2. The eight-channel model of flow (Pearce, Ainley & Howard, 2005)**

### **5.3 A review of publications that investigated flow within an online environment**

The flow model fitted well with the requirements for this study because it provided a means of analysing the emotional state of the learner as well providing a framework of components that can contribute to an optimal emotional state. A review of flow within an online environment was carried out in order to gain a deeper insight into flow and the potential methods of measurement of flow within an online environment.

This review examined 16 studies into flow within computer-mediated environments. Finneran and Zhang (2005) identified some differences in the field of flow in computer-

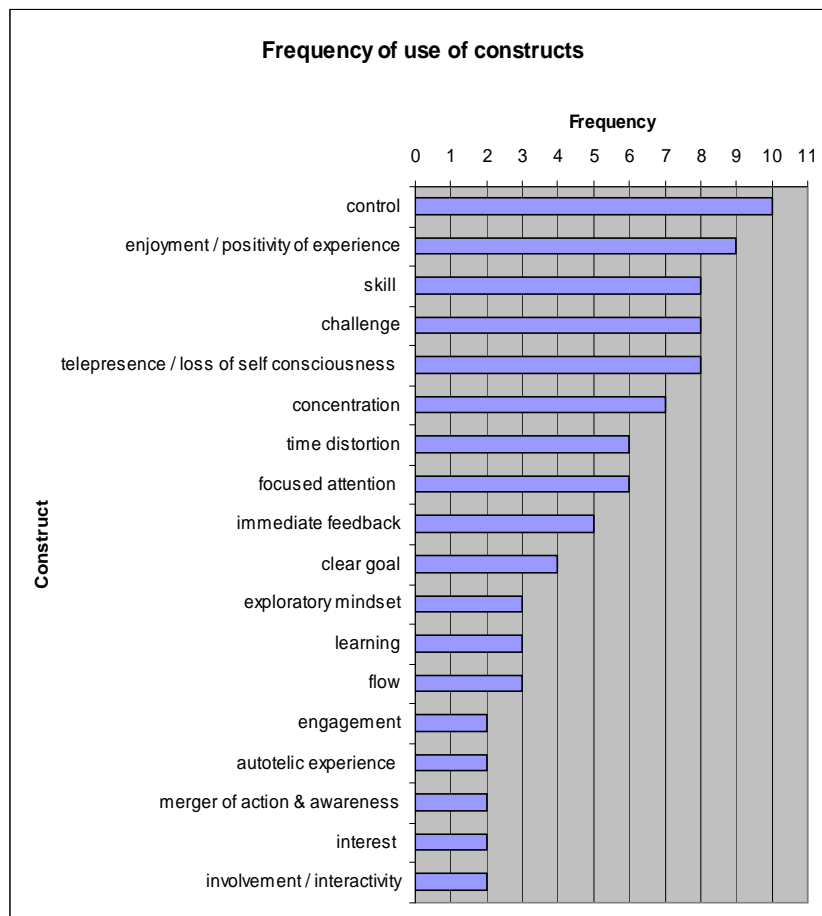


mediated environments. They reviewed several papers and identified different components and models of flow being used in the studies. These findings are supported by this review. The differences and similarities within these studies are examined by looking at:

- (i) The constructs of flow identified from the studies.
- (ii) The meaning of the constructs.
- (iii) The tasks used in the studies.
- (iv) The measurement methods implemented in the studies.
- (v) The questions used in the studies.
- (vi) The importance of the constructs of skill and challenge.
- (vii) Temporal stability of flow.

**(i) The constructs of flow identified from the studies**

Within the 16 papers reviewed, a set of 46 constructs of flow were identified, two pairs of which were combined to create a new total of 44 constructs. The construct of control appeared most often, along with telepresence, skill and challenge. Figure 5.3 shows an extract of the constructs identified, and the frequencies with which they appeared in the studies (excluding those that appeared only once).



**Figure 5.3. Constructs of flow identified in the literature review**

Telepresence was combined with loss of self-consciousness since one could argue that telepresence and loss of self-consciousness are the same thing, but that they are being described from differing angles. Loss of self-consciousness generally refers to a loss of awareness of the immediate surroundings. In order for a person to feel as though they are in a different location, they must surely lose an awareness of the immediate surroundings.

It could also be assumed that positivity of experience is the same as an experience of enjoyment when some of the definitions of enjoyment are examined:-

“The act or state of enjoying”, “The possession, use, or occupancy of anything with satisfaction or pleasure” or “Act of receiving pleasure from something”<sup>4</sup>. Thus these two components were also combined.

Interestingly the ten most frequently cited constructs correspond very well with the components put forward by Csikszentmihalyi as described in the previous section. Table 5.1 gives a comparison of the ten most frequently cited constructs identified in this review with Csikszentmihalyi’s components of flow.

**Table 5.1. Comparison of flow components**

Csikszentmihalyi components of flow	Most frequently cited constructs
Control	Control
	Enjoyment / Positivity of experience
Challenges Match Skills	Skill
Challenges Match Skills	Challenge
Loss of self-consciousness	Telepresence / loss of self-consciousness
Concentration	Concentration
Transformation of time	Time distortion
Focus	Focused attention
Feedback	Immediate feedback
Clear goals	Clear goal

There is a very good match between the two; the only apparent difference is that of enjoyment / positivity of experience which does not appear in Csikszentmihalyi’s components, but it could be surmised that positivity of experience or enjoyment is a condition or consequence of flow.

<sup>4</sup> Retrieved from <http://dictionary.reference.com/browse/enjoyment>

## **(ii) The meaning of the constructs**

This section examines the next apparent difference between the studies, the meaning of the constructs. While there are obviously different ways in which to describe what is essentially the same thing within the top ten constructs, the only discrepancies identified were where the studies were measuring ‘feedback’ and ‘immediate feedback’, ‘challenge’ and ‘perceived challenge’ and finally ‘control’, ‘sense of control’ and ‘sense of control to influence outcome’. These differences seem insignificant, in particular the difference between challenge and perceived challenge, as the questions were all aimed at the participant’s perception of the task. Probably the most significant of all of these is the difference between feedback and immediate feedback as one could argue that a participant may provide a positive answer when asked if they received feedback even if the feedback was not immediate. However, in general there was a strong consistency among the ten constructs. One could speculate that any differences may be due in part to the lack of a concrete definition of flow. Additionally, flow is an emotional experience, and as with most emotional experiences it can often be perceived and described in slightly varying ways. However, this should not detract from the overall notion that an emotional state has indeed been experienced. Despite the strong consistency among the constructs there is still an apparent lack of consistency in the conceptual model of flow.

## **(iii) The tasks used in the studies**

Of the thirteen papers that provided details about the task to be undertaken by the participants, two distinct groups were identified. The first was for general web browsing activities (Chen, 2006a; Chen, 2006b; Huang, 2003; Novak & Hoffman, 2003; Novak, Hoffman & Yung, 2000; Chen, Wigand & Nilan, 1999), with the only exception within

this group being the task from Skadberg & Kimmel's (2004) study where a specific web site was to be visited. The second group indicated a learning task to be undertaken (Choi, Kim & Kim, 2007; Konradt & Sulz, 2001; Nah, Guru & Hain, 2000; O'Broin & Clarke, 2006; Shin, 2006; Pearce et al. 2005).

It is obviously difficult to draw conclusions when comparing studies that cover such wide areas as general web browsing and online learning, given that both of these areas themselves can cover a very large range of activities. However, all of the studies did indicate that participants could reach a state of flow when in a computer-mediated environment, no matter if they were participating in a learning task or browsing the web. One may consider that this to be an indicator as to the importance of studying flow in online environments.

#### **(iv) The measurement methods implemented in the studies**

Thirteen of the papers reviewed utilised some form of online measurement tool.

Three of the studies surveyed the participants once via the web, along with other surveys such as the WWW User Survey (Novak & Hoffman, 2003; Novak et al. 2000; Chen et al. 1999). A further two studies surveyed the participants once at apparently arbitrary times (Shin, 2006; Huang, 2003), while the remaining eight studies surveyed the participants at specific times. Those that surveyed at specific times were further divided into two groups. The first group contained those surveyed more than once, generally at predetermined time intervals (Chen, 2006a; Chen, 2006b; Konradt & Sulz, 2001) or at the end of each learning task (Pearce et al. 2005) or when the user felt that their state had changed (O'Broin & Clarke, 2006). The second group were surveyed once only, upon completion of the whole task (Choi et al. 2007; Skadberg & Kimmel, 2004; Nah et al. 2000).

The predominant question format in these studies was of a modified Likert scale. Nine of the ten studies which provided information about the question format used a Likert scale or a modified Likert scale of measurement (Chen, 2006a; Chen, 2006b; O'Broin & Clarke, 2006; Shin, 2006; Pearce et al. 2005; Skadberg & Kimmel, 2004; Huang, 2003 Konradt & Sulz, 2001). Some of these also included other measurement methods, such as interviewing the participants (Pike, 2004).

#### **(v) The questions used in the studies**

Similarities were identified in the questions being put to the participants. Finneran and Zhang (2005) outlined the questions being used in six studies reviewed in their paper. They showed that of the six studies, only three showed a degree of similarity in the questions. Two of the three studies that showed similarities in the questions were based upon learning activities, with only Huang's (2003) study being based upon general web browsing with no specified task. Although these studies showed some similarity in the questions asked, there was a degree of difference between the wording of the questions. For example, in one study using a 5-point Likert scale, a question was asked to identify enjoyment under the sub-question of 'interesting'. Another study used the statement "Navigating this website was intrinsically interesting" whilst the last study used "I found the activities interesting". Although on the face of it these studies were all attempting to identify the level of interest the participant experienced, the way in which the questions were worded may well have led to variances in the responses. It is of course understandable that in some situations questions may need to be reworded to best fit the situation. For example, two of these studies measured the participant's level of boredom with the following statements: "The activities bored me" and "Navigating this

website bored me”. The latter was specific to a website, whereas the former was in fact used within a learning task, and could be applied to any task.

In the studies reviewed for this paper all the available questions were examined for the ten most frequently cited constructs of flow as shown in Table 5.1. Not all the studies provided the questions they used and not every study measured each construct, with only ten of the 16 papers reviewed providing information about the questions. Also most of the studies asked more than one question for each construct - generally one question worded positively and one worded negatively, e.g. “I felt that I had no control over my interaction with the web” and “This website allowed me to control the computer interaction” (Huang, 2003). This was presumably done to provide less leading questions.

The construct which appeared to be measured in the most consistent manner was concentration, with four out of five studies using the wording “I was absorbed intensely in activity”, and three using “I was concentrating fully on the activity.” The control construct showed consistencies in the wording of questions within seven studies which measured control, similar wording was used for four of them, with the only alterations in the wording being to fit the context. The rest of the constructs were measured with questions that were worded quite differently but implied similar meanings. The notable exceptions to the questions were challenge and skill. None of the questions within the four studies that asked about challenge or the three studies that measured skill showed any similarity at all.

The different descriptions of the measures of challenge and skill are examined further in the next section.

#### **(vi) The importance of the constructs of skill and challenge**

It was interesting that the constructs of challenge and skill should be so inconsistently measured within the papers reviewed when these are considered by some to be influential constructs of flow (Pearce et al. 2005; Chen et al. 1999). One could surmise that this is due to the nature of challenge and skill as they are so task-specific, although just because a task is specific does not mean that a generalised question cannot apply. For example in the paper-based versions of questions to elicit flow experiences, such as those provided by Csikszentmihalyi using the experience sampling method (which is described in section 5.4), the activity was unlikely to be known to the researcher, and the participant was asked to indicate what their main activity was and how they felt about it when they were asked to complete the questions. In particular the questions relating to challenge and skill asked “How challenging was it?” and “How skilled are you at it?”. This style of question could be applied to the broad range of tasks that can occur within an online environment.

#### **(vii) Temporal stability of flow**

Few studies have investigated the stability of flow over a short period of time. However, two studies which have gone some way towards this are those of Chen (2006a) and Pearce et al. (2005). Chen (2006a) found that during web browsing sessions the participants’ flow experiences did not change very much between the readings, which were taken at 5 and 8 minute intervals. Contrary to this, the study by Pearce et al. (2005) found that the ratings of flow, measured by a perception of skill and challenge, fluctuated from task to task. Each task was a small physics problem to be solved. One



reason for the difference between the findings of these two studies could well be due to the nature of the task involved. It may be that the web browsing tasks provided a fairly static level of challenge to participants, whereas each of the physics tasks provided varying degrees of challenge to participants and this caused their flow states to fluctuate. With this in mind one can see the potential for learning tasks to have a disruptive effect upon a person's state of flow due to the challenges these present, unless carefully designed so as to provide a sufficient challenge to the learner at all times to maintain that state of flow as shown in Figure 5.1.

### **Conclusions from the review**

Although there are many variations on the basic model, the fundamental idea of flow was adhered to, with the ten most frequently used components identified being shown to relate to Csikszentmihalyi's main components of flow. The main issue appeared to be the different interpretations of the meaning of the constructs, e.g. feedback could mean 'general feedback' or 'immediate feedback'.

The use of a Likert-type scale with statements was the most popular method of questioning. The methodology of providing two questions for each construct, one worded positively and one worded negatively presumably provided less biased results from the participants. Most differences between approaches were found when measuring the challenge and skill aspects of flow. These differences were perhaps due to the differences in tasks being used, although there are ways of standardising the approach even when using varying tasks. Despite these differences in interpretations of flow, the fact that all the studies indicated participants were entering a state of flow demonstrated that a state of flow could be achieved within an online environment.

The next section examines the methods of measuring flow.

## 5.4 Measuring flow

In this section various methods of eliciting a person's state of flow are described. These include the use of psychophysiological measures, the use of questionnaires and more specifically the use of the Experience Sampling Method (ESM).

While some researchers such as Pilke (2004) used interviews to elicit information about the participants' state of flow, many more researchers have made use of psychophysiological measures. In chapter 4 the use of such measures was discussed as a way of measuring participants' emotions when listening to music. Psychophysiological measures involve measuring a person's physical responses, such as the facial muscle activity, skin conductance or heart rate. These physical responses change as a person's emotional state changes (Picard & Daily, 2005). For example if a person experiences a stimulus which causes happiness then their facial muscles involved with smiling will be activated. Such measures were used by Partala and Surakka (2004) who recorded facial electromyographic responses from the zygomaticus major and corrugator supercilii muscle sites (the muscles which control smiling and frowning), in order to identify participants' emotional states. The participants were asked to carry out an interactive problem-solving task on a computer. When a pre-programmed mouse delay was experienced, the participant was exposed to either a positive or negative intervention or to no intervention at all. The psychophysiological measures indicated that the participants were smiling much more when they received the positive interventions than the negative interventions (Partala & Surakka, 2004). Wilson and Sasse (2004) used a combination of psychophysiological and subjective measures to identify subjects' responses to audio and video degradations. They found that the psychophysiological

measures did not always correlate with the subjective measures and they concluded that this was because the psychophysiological measures may have detected responses that the participants were either unaware of or could not recall in the post-session assessment.

Others have found similar problems when using both psychophysiological and subjective measures. For instance Kivikangas (2006) used psychophysiological measures in his study to assess the level of flow experienced by participants whilst playing a computer game. His results indicated that although some of the psychophysiological measures correlated with the self-reported measure of flow, others did not. However, he concluded that the reason for this may have been due to the design of the experiment.

While psychophysiological tests can provide valuable data on a subject's emotional state at any given time, the practical use of these measures is currently limited as many of the technologies require participants to be 'wired up' to machines. It is very difficult to simulate 'natural' surroundings when running tests as participants would normally be required to be in a laboratory environment. Another drawback to using these measures is that they are usually very resource-expensive, and this can be a limiting factor to their use in many studies.

There are of course some situations in which the use of psychophysiological measurements is just not practical, such as in the study by Pates et al. who examined the flow state of netball players who were playing while listening to music. One could imagine that it would be very difficult to 'wire' people up whilst they were involved in such an active sport (Pates, Karageorghis, Fryer & Maynard, 2003).

## **The Experience Sampling Method**

Many of the initial studies carried out into flow used the Experience Sampling Method (ESM) as a means of measuring flow, and this has remained a useful method of measuring psychological phenomena including flow experiences that occur in the daily lives of individuals, (Chen, 2006a; Christensen, Barrett, Bliss-Moreau, Lebo & Kaschub, 2003). The ESM was originally a paper-based questionnaire format that was used to elicit a person's emotional state at a given time. This required a participant to carry around a small booklet within which were a set of questions to be answered. Each page of the booklet contained the same set of questions to be answered by the participant, one page being used for each evaluation throughout the study. The participant would be alerted as to when to fill in the next page of the booklet by a beeper, or a pager. This method of data collection provides a 'snap shot' of how the participant felt just before they filled in the questions. Initial studies followed participants for a period of several days or weeks in order to gain an insight into their varying emotional states during their daily life (Csikszentmihalyi & Larson, 1987).

The ESM has since evolved and become digitized (Chen, 2006a) and is also being utilised in different timescales and different environments (Novak & Hoffman, 2003; Chen et al. 1999). The original version of the ESM was administered on a time-dependent basis, i.e., it was unknown what task or activity the participant was undertaking when the beeper was sounded. It would be triggered at a predetermined time indicating participants were to fill in the booklet. However, with the digitisation of the ESM it is now possible to create event-triggered sampling, whereby the participant is requested to answer questions at a particular point during a task or activity (Pearce et al. 2005). Alternatively the participant may be prompted at set-timed intervals (Chen,

2006a) or at random times. This flexibility has enabled the ESM to be applied to a variety of situations within a computer-mediated environment.

There are of course intrinsic problems with this style of measurement. As with any form of measurement that relies upon the participant recalling a feeling, emotional state, event or situation, the accuracy of their recall is open to debate. The accuracy of the reported emotional state is also open to question as they may report feeling happy, but that happiness was simply the dominant emotion available to the participant's conscious awareness (Christensen, et al. 2003). Perhaps there were other stronger emotions taking place in their subconscious. One could also assume that there may be a potential issue as to whether the participant is just reporting on the last emotion they were aware of or the strongest emotion they experienced over the period leading up to the questions. Another in-built problem with the ESM is that a state of flow may well be disrupted by the prompt to fill in the questions, be it a beeper, pager or a popup on a web page.

After pointing out these inherent problems with the ESM, one could wonder if there is any way of validating this measurement tool at all. Many research studies have used the ESM both in its original paper-based format (Csikszentmihalyi & Larson, 1987) and in the digitised version (Chen, 2006b; Shin, 2006; Skadberg & Kimmel, 2004; Huang, 2003; Konradt & Sulz, 2001) and there have also been studies carried out with the sole purpose of establishing the validity and reliability of the ESM (Chen, 2006a; Csikszentmihalyi & Larson, 1987). Other researchers such as Diener (1994) have studied the use of the ESM within the domain of 'subjective well-being', and found it to be of value when gathering data on participants' emotional states.

Having discussed various models of emotions and methods of collecting data about peoples' emotional experiences, it was decided that the concepts of flow would be used in the study along with the Experience Sampling Method of collecting data. As has been described there is much evidence to show that flow can be experienced in an online environment. The next chapter describes the development of the music and animation study including further development of an ESM for use with this study.

## **CHAPTER 6**

### **THE MUSIC AND ANIMATION STUDY**

In this chapter the development of the main experiment of this research is described, drawing upon all of the various domains discussed in the previous chapters. In chapter 1 e-learning was described, while in chapter 2 the uses of music were discussed and it was identified that there was little study of music within e-learning contexts. In chapter 3 the aims of this research were outlined and problems associated with online research identified. The chapter also detailed the pilot experiment. Following on from this, in chapter 4 a sub-section of research described the categorisation and eventual selection of music for use in the music and animation study. At this point in the research it was apparent that there was a need to be able to identify a learner's emotional state. Hence in chapter 5 emotional models were considered, including flow. It was decided that the model of flow along with the Experience Sampling Method would provide a suitable means for the elicitation of the learner's emotional state during the experiment.

#### **6.1 Further hypotheses**

This research aimed to identify the effects of music and animation upon a learner:

##### **Hypothesis 1**

The inclusion of music and animation in the interface will affect a learner's perception of their emotional state and their learning attainment in an e-learning environment.

In order to achieve this the most appropriate method was to use four different configurations within an e-learning situation: the use of music and animation, music alone, animation alone and no music or animation. The use of these four different situations, shown in Figure 6.1, would allow for comparisons to be made between them and identify the effects of the individual interventions, i.e., the music and the animation. The situation with no music or animation would serve as the control, offering a baseline for comparison.

	<b>Animation</b>	<b>No Animation</b>
<b>Music</b>	<b>Situation 1</b>	<b>Situation 2</b>
<b>No Music</b>	<b>Situation 3</b>	<b>Situation 4</b>

**Figure 6.1 The four different learning situations**

Having decided that the model of flow would be used to map the learners' emotional states, the following sub-hypotheses were created to enable testing of each aspect of the main hypothesis with regards to the learning attainment and emotional state:

### **Hypothesis 1.1**

There will be a difference in the learner's ability to enter a state of flow between the four different learning situations (no music and no animation, music only, music and animation, and animation only).

### **Hypothesis 1. 2**

There will be a difference in the learning attainment within the four different learning situations (no music and no animation, music only, music and animation, and animation only).



Following on from the literature review about flow in online environments it was decided that eight constructs of flow would be considered for this research. These eight were the constructs put forward by Csikszentmihalyi; they also appeared among the most commonly used constructs of flow in other research. Further hypotheses were proposed about the effects of music and animation upon these constructs: a summary of these is shown in Table 6.1.

## Hypothesis 2

The inclusion of music and animation will affect some of the flow constructs, but not all.

**Table 6.1 The hypothesised effects of music and animation**

Hypothesis number	Construct (As described by Csikszentmihalyi )	Hypothesised effects of music and/or animation
2.1	A clear goal	None
2.2	Feedback	None
2.3	Challenges match skills	None
2.4	Concentration	Increased
2.5	Focus	Increased
2.6	Control	Decreased
2.7	Loss of self-consciousness	Increased
2.8	Transformation of time	Increased

In particular it was hypothesised that the goals, feedback and the level of challenge and skills required would be unaffected by the addition of the music and/or animation since the goals of the learning experience and the feedback provided would remain unchanged. The challenge of the learning experience was also expected to remain unchanged and it was not anticipated that the participant would require greater skills to cope with the addition of the music and/or animation.

However, it was hypothesised that a participant's level of concentration, focus, loss of self-consciousness and transformation of time would be increased with the addition of the music and/or animation. It was anticipated that the inclusion of these extra elements would lessen the effects of any external distractions, thus increasing the potential for the participant to concentrate. Since the inclusion of music and/or animation aimed at creating a more immersive environment than was experienced with no music or animations, it was expected that the levels of focus, loss of self-consciousness and transformation of time would also be increased in participants when watching the presentation which included music and/or animation.

The level of control experienced by the participant while watching the presentation was anticipated to decrease. The reason for this hypothesis is that when there was no music or animation the participant would select when to move to the next slide without any prompting as to when they should do so, i.e., they could read the text at a speed that suited them and select to move to the next slide in their own time. However, when music is added there is a possibility that the participant may feel obliged to stay on that slide until the music has finished, even if they have read all of the text on that slide and they are ready to move on. This tendency is increased further when the animations are included since much of the text on the slide may not even be visible. Thus the participant has to wait for the text to appear and this forces a minimum reading speed upon the participant. It may not be a problem for those who read more slowly than the rate that the text is appearing but may pose a feeling of lack of control to those who read more quickly than the text is appearing.

## **6.2 Experiment design**

Having identified that there would be four different learning situations, the experimental design was developed. During this process several experimental designs were considered, and then an experimental model was constructed. The presentation subject was selected and the potential sample of participants identified.

### **Design considerations**

The first design consideration was whether the test should be run as a deep test or as a shallow but broad test. In other words, whether each participant would be presented with each of the learning situations (shallow, broad test) or only be presented with one learning situation (deep). There were pros and cons to each of these designs, with a deep design meaning participants would not be influenced by the previous learning situation that they were exposed to and thus a less biased result could be anticipated. However, to collect enough data to formulate any meaningful results would mean that large numbers of participants would have to be sought as there would need to be four separate groups of participants. There could be an alternative option for participants who may not have audio output capabilities on their computer as they could be redirected to a non-audio situation. Another advantage of this approach would be that the data could all be collected at the end of the presentation; this would reduce the risk of the data collection process interrupting the participant's state of flow.

Conversely, if the shallow test design was selected then the requirement of large numbers of participants would be reduced, but the results might be subjected to bias as the participants could, for example, have watched the music and animation situation first and the animation situation second and might feel the animation is less stimulating

than the combination of music and animation they had just seen, and thus 'mark' it lower. Of course if they had viewed the animation prior to the combination of music and animation they could have felt the animation to be unusual and very stimulating and thus marked it higher. For this reason the shallow design would need the learning situations to be presented to the participants in a random order to negate this effect and 16 variations of the test would need to be created to provide a full coverage of randomised presentation of the situations. This could potentially require a larger number of participants again to ensure that enough participants viewed each of the variations. Using this approach would also carry the disadvantage that if the four situations were to be presented within the one presentation then the participant would need to be answering questions part way through the presentation between each intervention situation. The resulting interruption might lead to the participant leaving a state of flow. Alternatively the design could have each participant watching four separate presentations, each one with the different learning situations, and answering the questions at the end of each one. However, this would be much more time-consuming for the participants and could place a considerable cognitive load on the participant if they were all to be viewed one after the other. They could be spaced out, but this in itself could create potential issues of ensuring that all of the participants had the same amount of time between presentations. If the participants were all watching the presentations with different amounts of time between them this could lead to an additional variation between the situations. There would also be a need for every participant to have audio output facilities from their computer.

There are various combinations that fall between these two designs, such as having each participant being presented with the no music and no animation situation followed by

one other situation. The first situation would then act as the control for that participant followed by the situation with the intervention of either music or animation or both.

After reviewing all of the pros and cons of the different approaches to this test design along with the results from the pilot study (where the participant preferences for the duration of the music were to have small sections of music interspersed throughout the presentation rather than being played all the way through), it was decided to use the deep approach. It was judged that this approach would provide the least biased results. Although the third option mentioned above – the combination of no intervention to provide a control followed by an intervention situation – has the potential to be a very sound experimental design, it was also considered important not to overload the participants with too much to do and this approach would have needed a set of questions at the end of each presentation if viewed one after the other.

### **Experiment design**

Many considerations were taken into account when designing this experiment, such as where the participants would be taking the test, i.e., would they be within the controlled environment of a lab or in a remote location. The pros, cons and associated difficulties of each situation were examined and are described later. Other considerations included which data were required to enable the hypothesis to be answered, which technologies should be used and which e-learning subject the participants would study during the experiment.

In the early stages of the design process the pilot study provided a good basis for identifying how the music and animation could be choreographed and incorporated into

a learning presentation. However, the pilot study provided only one presentation that played music and animation.

The use of the deep approach confounded the need for four different learning situations to be used. In order to identify the effects of the music and animation it was important to minimise the variables between the four learning situations so that comparisons made between the situations reflected the addition of music and animation rather than differences in the presentation content.

For this reason all of the presentations would be as similar as possible and the only difference would be the addition of the music and the animations.

The presentation with no intervention, i.e., no music or animation, would form the basis for the other presentations. It was important that this presentation was not so basic in its design that it would be less appealing than the other presentations by the simple virtue that it was 'dull'. Thus it would need to provide an interesting interface design that would lend itself to further development into an animated format. The two screen shots below indicate how the same piece of content may be presented in a dull, even difficult to read, manner (Figure 6.2) or in a more interesting, brighter and easier to read manner (Figure 6.3).

## Brainstorming in your head

There is another method of brainstorming but it is not recommended

Internalise all your thoughts and write the assignment spontaneously, without doing any preparation, reading, thinking or planning.

Advantages:

Suits the totally unprepared!

Disadvantages:

Tends to be unsuccessful unless you have an ordered mind, a good memory and an ability to invent foolproof data, examples and other forms of 'evidence' (a pretty tall order!)

**Figure 6.2 Example of a 'dull' interface**

## Brainstorming in your head

There is another method of brainstorming but it is **not** recommended

Internalise all your thoughts and write the assignment spontaneously, without doing any preparation, reading, thinking or planning.

**Advantages:**

- Suits the totally unprepared!



**Disadvantages:**

- Tends to be unsuccessful unless you have an ordered mind, a good memory and an ability to invent foolproof data, examples and other forms of 'evidence' (a pretty tall order!)



**Figure 6.3 Example of a more 'interesting' interface**

### Experimental model

The next stage of the design process was to decide upon the experimental model.

Having decided that each participant would be presented with just one of the four

learning situations, the next stage was to identify the data that would need to be collected in order to assess the hypotheses.

Three data sets were identified, which were:

Pre-test data – to identify the participant’s current level of knowledge about the subject.

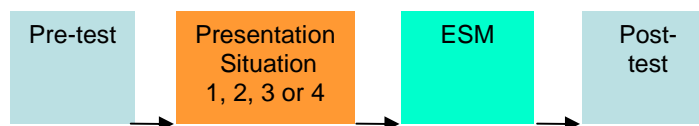
Post-test data – to identify the participant’s level of knowledge after the presentation.

Flow data – to capture information about the participant’s emotional state and their level of flow during the presentation.

Having identified the types of data to be captured several test models were created and the benefits of each assessed.

### **Test design 1**

The first of the designs outlined the basic need to capture data. Firstly the participant would be asked pre-test questions about the subject of the presentation. This pre-test would enable a participant’s prior knowledge of the subject area to be determined. Following on from this the participant would then watch the presentation, being allocated one of the four situations to watch. Then they would answer some questions to determine their state of flow during the presentation – the ESM questions – and finally they would answer the post-test questions (see Figure 6.4).



**Figure 6.4. Test design 1**

(presentation situations 1,2 and 3 represent the treatments and 4 the control)

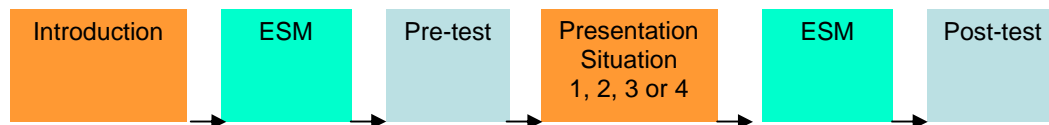


## Test design 2

The second design provided a more comprehensive method as it included an introduction to the test followed by an ESM test before continuing in the same manner as the first design.

It was considered that the inclusion of an introduction would be important if the test was to be run from a remote location. Even if it was to be run in a lab situation, having all participants introduced to the test in the same manner would negate any possible bias that the researcher may have inadvertently caused while introducing the participant to the test.

The additional ESM test prior to the pre-test and presentation was also included in this design (see Figure 6.5) since the participants could have arrived to take the test and be in a particularly unreceptive mood, e.g. perhaps they were having a bad day or had suffered a particularly unpleasant experience. This could influence their perception of the presentation and if the ESM were only to be recorded at the end of the presentation the results could show a low propensity to enter a state of flow, whereas it might have been that prior to the presentation their likelihood to enter a state of flow was even lower. Thus one could conclude that the presentation increased their potential to enter a state of flow. The only way to be sure of any increase or decrease in the flow potential of the participant would be to take a pre- and post-ESM reading.



**Figure 6.5. Test design 2**

(presentation situations 1,2 and 3 represent the treatments and 4 the control)

### Test design 3

This test design expands further on the second test design as it could be argued that the introduction and the pre-test could have an influence upon a participant's state of flow. Thus there are three stages where the ESM is recorded (see Figure 6.6). Here the pre-test would also be administered prior to the introduction.

The added benefit of this design is that the participant would become familiar with the ESM process and thus any anxiety they may experience while completing the ESM should be lessened. The results from the first ESM would be discounted as this would be considered a practice for the participant. The results from the second and third ESMs would be the relevant ones.



**Figure 6.6. Test design 3**

(presentation situations 1,2 and 3 represent the treatments and 4 the control)

Several further variations on each of these designs were considered, such as in test design 1 the ESM could have been given after the post-test. However, this design was discarded since the ESM results could then have related to the post-test more than to the presentation. One of the key aspects of the ESM is that it should be administered as soon as possible after the event or task to which it is related. Hence it was important to keep the ESM immediately after the presentation. Despite the risk that a participant's learning attainment results might have been impaired due to focussing on the ESM questions before progressing to the post-test, it was considered the knowledge gained would be longer lasting than the emotions felt during the presentation.

Taking into consideration the data to be collected and the cognitive and time loading on the participant, test design 2 was selected. It provided a good balance between collecting the relevant data and not asking the participant to do too many practice runs, and thus would not unnecessarily lengthen the duration of the test. Test 1 was considered to be a little too simplistic as it would not provide an introduction to the participant and would only record the ESM after the presentation, thus limiting the amount of data collected, although it would have the benefit of being shorter in duration. At the other end of the scale, whilst being very comprehensive, test design 3 could have been prohibitively time-consuming for the participant along with the potential for participants to become bored of filling in ESM questions, possibly leading to distorted results.

Additionally, there was the option to have several ESM question sets during the presentation, either after specific slides or at set time-intervals. However, as it was anticipated that the level of challenge and skill required whilst watching the presentation was unlikely to vary it was thought better not to interrupt the presentation with questions, but rather allow the participant to view it all before presenting the ESM questions. This decision was based upon the findings of previous research, as discussed in chapter 5 section 5.3.6, which indicated that where the level of challenge and skill of a task remain reasonably static it is unlikely that a person's state of flow will fluctuate.

### **Presentation subject**

The next stage was to select a suitable subject matter for the presentation. In the pilot study the subject was Java programming, but this was selected by default. For this test

the subject and content needed to be as emotionally neutral as possible so that it would not be the content which triggered emotional responses in the participant, but the method of delivery. In order to be able to draw on as many potential participants as possible it was also decided to select a subject that was not domain specific. The subject selected was learning styles and study methods as this was a subject area relevant to all domains of study and might also be of value to participants in learning more about this subject. The content was developed from existing material from the University of Dundee's 'Advance' website, which provides general information about a range of 'life and study skills'.

A prototype presentation without music or animation was developed in PowerPoint and this was evaluated by academic skills advisors, amended as appropriate, and then re-evaluated.

The possibilities of recording data about participants' learning styles had been considered during the development of this experiment. However, it was decided that it would make the whole test too lengthy if the learning styles were to be assessed as well as the learning attainment and the emotional state, since most assessments of learning styles involve a sizeable set of questions. Since the subject of the presentation was to be about learning styles and study methods it was appropriate to record the participants' self-assessed learning styles; this was to be done as part of the presentation so that it fitted seamlessly into the test and was not posed as a separate set of questions, but rather as an interactive element of the learning presentation. This provided additional data about the learner and whether their self-assessed learning styles had any effect upon their state of flow or learning attainment.

Hypothesis 3 was then formed:

**Hypothesis 3**

The learner's learning styles will have no effect upon their learning attainment or their level of flow.

**Hypothesis 3.1**

The learner's perception of their learning styles will have no effect upon the learning attainment.

**Hypothesis 3.2**

The perceived learning styles will have no effect upon the learner's ability to enter a state of flow.

**6.3 Potential sample**

Prior to further development of the music and animation presentations it was necessary to decide where the participants would be recruited from as this could have an impact on the types of technology used to develop the presentations. For example, if the participants were to take the test in a lab situation where the researcher provided the computer and the software, the technology used would only need to be compatible with the hardware and software used in the lab. However, if participants were using their own computers then the technology used would potentially have to be compatible with a wide range of hardware and software.

Many studies into e-learning are domain specific, which can limit not only the number of recruits, but also restrict the recruits to a very specific cohort of people. One of the benefits of using the subject of learning styles and study methods was that the content would be appropriate for a wide range of students from different subject areas.

Recruiting from a wide range of students would mean that potentially there could be a similarly wide range of participant attributes, such as different age groups and people with different learning styles. Students from colleges and universities and secondary schools could all be potential participants.

With the potential sample of participants being large in number, this would make it unfeasible to have all participants come to the lab, and thus it was decided to run the test online. This had the added advantage that participants would be able to take the test at a time that suited them, as well as a location that suited them. This principle follows the ethos that e-learning materials are geographically independent and available 24 hours a day 7 days a week. Another advantage of selecting this method for administering the test was that the participant would be in familiar surroundings (or at least it would be expected that they would be in surroundings generally used for conducting computer-based tasks), and thus they should feel less anxious than if in an unfamiliar lab situation. However, selecting this method carries its own problems, as discussed in chapter 3. Issues include not knowing if the participant was being distracted by the goings-on around them, if they were alone or with others, if they encountered any technical difficulties during the test, what quality their audio output was, or even if they had any audio output at all.

Although there is obviously much less control over the participants' environment and hardware used, an online environment was still considered to be the most beneficial method since it provided the most natural e-learning setting. Also, since the numbers of potential participants were so much greater than could be accommodated in a lab situation, it was hoped the potential volume of data collected would render insignificant the effects of the occasional participant's results being affected by things such as distractions or technical difficulties. Nonetheless strategies to deal with these potential issues as indicated in chapter 3, were examined and incorporated into the test design

where appropriate, such as the question design allowing for an opt-out option. Not all of the strategies to overcome these issues would be successful, for example recording the IP address of each user would seem to prevent repetition. However, it was most likely that multiple IP addresses would be seen since the target group of participants would be students and they may well be using the same computers at different times in the IT suites.

#### **6.4 Ethical approval**

Ethical approval for this study was obtained in accordance with the guidelines from the College of Art, Science and Engineering, University of Dundee. It was made clear to participants that their data was stored anonymously and that they could leave the study at any time without any undue consequences. All participants were required to indicate that they had read and understood the terms as laid out in the informed consent form before continuing with the test. This was included within the first slide of the introductory presentation. Additionally, prior to school children being invited, the head teacher of the school was asked to give consent for the children to be invited to take part.

#### **6.5 Experiment development**

This section describes the development of the experiment. This involved the development of several distinct areas which were to appear seamless to the participant. In order for this to take place it was necessary to first decide upon the architecture of the technology that would be used to provide this. Then the presentation was developed along with the presentation data collection process. The pre, post and ESM question set

was developed and lastly the introductory materials were developed and a pilot of this experiment was carried out.

### **Architecture**

In the pilot study a PowerPoint presentation was used and music and animation was added to it. The questions were then presented in a web page consisting of HTML and PHP with a MySQL database behind. Whilst the PowerPoint technology was suitable for the pilot study, it would not be compatible enough for the music and animation study as it would not be evident if every participant's computer could open and play a PowerPoint presentation. Additionally, since there was now also the need to capture data from within the presentation itself (the participant's self-reported learning styles) PowerPoint would not support this.

Various technologies were considered, with requirements being that the presentation should:

- be delivered over the web
- be fully compatible with a wide range of web browsers
- have small file sizes
- have good quality sound
- ensure participants have the ability to move seamlessly between different sections of the test
- have the ability to record data collected into a database
- have the ability to pass information from one section of the test to another to ensure that data collected would be stored in relation to each participant
- provide a user-friendly interface



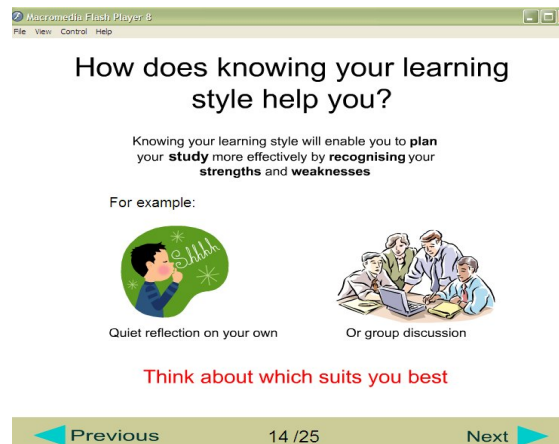
Although there were several technologies capable of fulfilling these requirements, the following technologies were employed:

- Adobe Flash
- HTML
- PHP
- MySQL

The Adobe Flash presentation would be able to provide a user-friendly PowerPoint-style presentation, also incorporating the music and animation elements whilst maintaining minimum file size. Flash also provides great compatibility with the majority of browsers. The use of Flash would allow the presentation to be fully integrated into a web-based application within which the questionnaires (pre-test, post-test and ESM) could be presented. The results from the questionnaires could then be passed to a MySQL database via PHP files. The information gathered in the Flash presentation about the learning styles could also be passed to the database via PHP files. Information about the participant (a simple form of identification, being an ID number automatically generated by the system) would be passed from one page to another to ensure all data collected could be stored in the same record and not be confused with another participant. Again the use of this technology would support the passing of data from one page to another as required.

## Presentation design

The first presentation was developed in Adobe Flash, and was based upon the original prototype PowerPoint presentation previously developed. The only addition was the inclusion of navigation buttons at the bottom of the screen to allow the participant to move forward and back through the slides (Figure 6.7). Navigation through the slides would also be possible using keyboard controls, by using the tab key to select the navigation button required and then pressing the return key to activate the control.



**Figure 6.7** Screen shot of one of the slides from the presentation

This navigation would allow the participant to set their own pace through the presentation. This ability to select the pace was one of the recommendations put forward as part of the Cognitive Theory of Multimedia Learning (CTML) (Moreno & Mayer, 2007), as discussed in chapter 1, which suggests that students learn better when able to control the pace of presentation. Other principles of CTML were also incorporated, such as providing explanatory feedback in the form of a progress counter indicating the current slide number and number of slides in total. This also served to guide them through the learning process.

The remaining three presentations were created by incorporating music into six of the 25 slides for one presentation, adding in animation for the next presentation to create the music and animation situation. Lastly the animation-only presentation was created by removing the music from the music and animation presentation. A summary of this process is shown in Table 6.2. The interventions would take place on the same six slides for each of the presentations; these were on slides 2, 9, 13, 20, 22 and 25. It was not possible to spread the intervention slides out equally through the presentation as not every slide had appropriate content for use with the animation.

Developing the presentations in this way ensured that the only differences between the presentations were the addition of music and/or animation.

During the remainder of this document, the different learning situations will be referred to by the following abbreviations:

Neither music nor animation – N

Music only – M

Music and animation – MA

Animation only – A

**Table 6.2. Summary of the presentations**

Abbreviations	Content	Summary
N	Neither music or animation	This presentation provided the content in an interesting and informative manner.
M	Music only	This was an exact replica of the N situation in terms of the content, but on the six intervention slides music was played to the learner.
MA	Both music and animation	The content was the same as the N situation but here on the six intervention slides the same music was played as for the M situation but animation was choreographed to the music.
A	Animation only	For this presentation the same animations that were played in the MA situation were played here, but no music was played.

It is worth reiterating that the animation used in this study refers not to cartoon-style animation, but the animation of screen elements, e.g. a word on the screen changing colour or becoming larger or smaller, otherwise known as temporal or dynamic typography.

All of the presentations were informally evaluated and one problem was identified that concerned the animation presentation (A). It was thought that the animations needed to be speeded up, by means of shortening the delays between different animations. Since the timing of the animations was the same as in the MA situation yet without sound, this caused the time between each animation element being executed to seem far too long. When music was playing the delays were accepted without any problem. For this reason the timings of the animation were speeded up, and then were evaluated and were accepted. Table 6.3 shows the total length of time the intervention slides took.

**Table 6.3. The total time the intervention slides took to run**

Presentation situation	Total run time of intervention slides
MA	235 seconds
M	235 seconds
A	205 seconds
N	N/A

### **Presentation data collection**

As the participant progressed through the presentation, various data were collected. Participants' self-reported learning styles were collected by asking participants to select from the four Myers-Briggs Type Indicators (MBTI) that they felt they most identified with (Figure 6.8). This was after a description of the MBTI had been presented in order to ensure participants had a good understanding of the different indicators. There were

key points under each of the indicators to help participants recall the meaning of each indicator, and they were also able to navigate back to read a full description about each of the indicators as necessary. Radio buttons were used for each of the indicators, meaning they could only select either Extroversion or Introversion, and so on for the other indicators. Upon selecting from the four indicators a short message would be displayed explaining the sort of characteristics a person of this type would be likely to have. In the example screen shot shown in Figure 6.8, the indicators selected are Extroversion, Intuition, Feeling and Judging. The message at the bottom of the screen then suggests that the person is likely to be “sensitive, innovative, adaptable and optimistic”. There were different suggestions for each of the sixteen different permutations of the MBTI.

Macromedia Flash Player 8

File View Control Help

Which of the 4 Myers-Briggs Type Indicators do you identify with the most?

select from each of the 4 indicators

1. ☒ **Extroversion** / ☐ **Introversion**  
action and interacting with others ideas and thinking about things alone

2. ☐ **Sensing** / ☒ **Intuition**  
real things, facts and structure hunches, gut feelings and intuition

3. ☐ **Thinking** / ☒ **Feeling**  
logic, clear goals and objectives human values and keen to avoid conflict

4. ☒ **Judging** / ☐ **Perception**  
decisive, self-regimented, focused and less regimented, adaptable, spontaneous and

According to the Myers-Briggs Type Indicator you are likely to be:-  
 sensitive, innovative, adaptable and optimistic

◀ Previous Next ▶

**Figure 6.8 Myers-Briggs Type Indicator selection slide**









Later in the presentation a similar process would be carried out, but this time for Gardner’s Multiple Intelligences (GMI). This again represents different categories of preferred learning styles, such as a person preferring to learn in a verbal or linguistic

manner whereas another person might prefer a more visual or spatial representation. For this selection a list using check boxes rather than radio buttons was provided (Figure 6.9) since a person may have several different preferences. As with the MBTI the descriptions of GMI had already been provided and could be navigated back to for clarification if necessary.

Macromedia Flash Player 8  
File View Control Help

## Which of Gardner's 8 intelligences relate to you?

Tick all that apply

 <input type="checkbox"/> 1. Verbal / Linguistic	<input type="checkbox"/> 5. Body / Movement 
 <input type="checkbox"/> 2. Logical / Mathematical	<input type="checkbox"/> 6. Musical / Rhythmical 
 <input type="checkbox"/> 3. Naturalist	<input type="checkbox"/> 7. Interpersonal 
 <input type="checkbox"/> 4. Visual / Spatial	<input type="checkbox"/> 8. Intrapersonal 

◀ Previous
Next ▶

**Figure 6.9 Gardner's Multiple Intelligences selection slide**

Collecting data about the participant's learning styles was considered in the earlier stages of the experimental design. This was not pursued as it was felt that there would be too many questions for the participant to answer, since most methods of identifying a person's learning styles involves them answering a substantial question set. However, since the subject matter of the presentation meant that the participants would be well informed about learning styles, this lent itself very well to the participants self-reporting their perceived learning styles on the MBTI and GMI axis with minimal additional load on the participants. This data would allow analysis of the effects of participants'

perceived learning styles on their emotions and learning and also their preferences for the different interventions.

Further data was collected about the participants' viewing habits during the presentation. These included the time they spent viewing the whole presentation and the time spent viewing just the intervention slides. This would allow deep analysis of any differences identified between the different situations. The number of times a participant returned to a previous slide was recorded. All data was recorded from within the Flash application and was then passed to the MySQL database via the PHP file directly upon completion of the presentation.

### **Development of the ESM**

A set of ESM questions were developed from those evaluated during the literature review described in chapter 5. Two statements were each provided for seven of the eight components of flow, as shown in Table 6.4.

**Table 6.4 The ESM statements**

<b>Component of flow</b>	<b>Statement</b>
<b>Clear goals</b>	I knew clearly what I was supposed to do.
	I knew where I was and knew where to go next and what to do next.
<b>Concentration</b>	I was absorbed intensely in the activity.
	I was concentrating fully on the activity.
<b>Focus</b>	I was aware of distractions.
	I thought about other things.
<b>Control</b>	I felt frustrated.
	I always felt in control.
<b>Loss of self-consciousness/telepresence</b>	I felt that during the presentation, I was more in the "computer world" than the "real world" around me.
	During the presentation, I forgot about my immediate surroundings.
<b>Transformation of time / time distortion</b>	I was so focused that I completely lost track of time.
	Time went faster than I thought and I did not even sense it.
<b>Feedback</b>	I got direct clues as to how well I was doing.
	I knew how well I was proceeding.


Two questions were asked for each component to reduce the likelihood that the wording of the questions might have an influence upon a participant's answers. The components of challenge and skill were dealt with separately and are described later. Statements were presented along with a 5-point modified Likert scale – strongly agree, agree, neither agree or disagree, disagree, and strongly disagree. It was decided to use a 5-point modified Likert scale as opposed to a 7- or 9- point scale as the 5-point scale would provide a clear indication of positive or negative values as well as a neutral option without overburdening the participant with additional choices. These statements were presented as a set of 14 questions with five radio buttons to select from next to each question as shown in appendix G. Radio buttons were used to force the participant to select only one option from the modified Likert scale. To ensure that the order of the questions would not influence the answers, five sets of randomised questions were used. Each participant would be presented at random with one of the five sets. Sets of randomised questions were used as it was felt that there would be less cognitive loading on the participant if the ESM questions were presented in the same order for both the ESM prior to the presentation and the one after the presentation. If the question order had been different, participants might be further distracted from their immediate feelings about the presentation. As the aim was to minimise interferences between the presentation and the eliciting of the participants' feelings, the question order remained the same throughout. For logistical reasons, sets of questions were used rather than generating a random order for questions in the first ESM and then mapping that order to the second ESM.

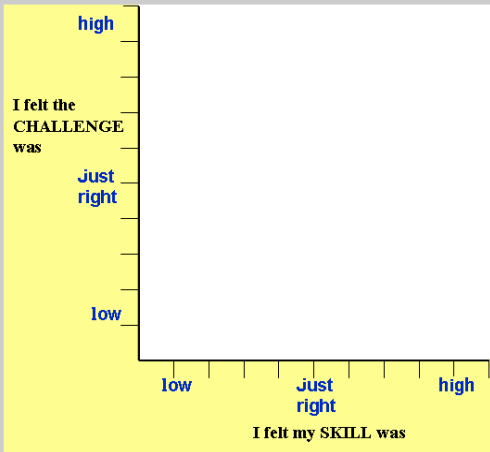
The data recorded from the ESM would provide a score for each of the components of flow, which would then indicate the level to which the participant was experiencing that



component of flow. These scores could then be added together to provide an ESM score. This ESM score would provide an indication of the participant's likelihood of being in a state of flow. Of course this score would not provide an absolute reading of the participant's state of flow since presenting a high level of these components of flow does not guarantee they are actually entering a state of flow. However, it would greatly increase the possibility of them entering a state of flow (Shin, 2006; Finneran & Zhang, 2005). Thus it was assumed that the higher the ESM score, the more likely that a state of flow had been entered.

There was also a need to capture data about the participant's perceived level of skill and challenge occurring during the learning experience and so a graph was presented to the participants. The x-axis represented skill and ranged from 'low' through to 'just right' and then to 'high'. The y-axis represented the challenge and it too ranged from 'low' through to 'just right' and 'high'. The graph was divided into nine sections. The sections were not numbered and the participants were asked to select the general position that best fitted their level of skill and challenge. These nine divisions represented the eight channels from the eight-channel model of flow with a small area in the centre being the ninth division. The participants were asked to drag and drop a marker into the appropriate position on the graph, to indicate the level of skill and challenge they felt they experienced (Figure 6.10). To ensure that the participants fully understood how to position the marker on the graph they were able to view an example which described the positioning in more detail.

Think about how you felt during the presentation then drag and drop this ball  into the appropriate place on the graph below. [Show me an example](#)



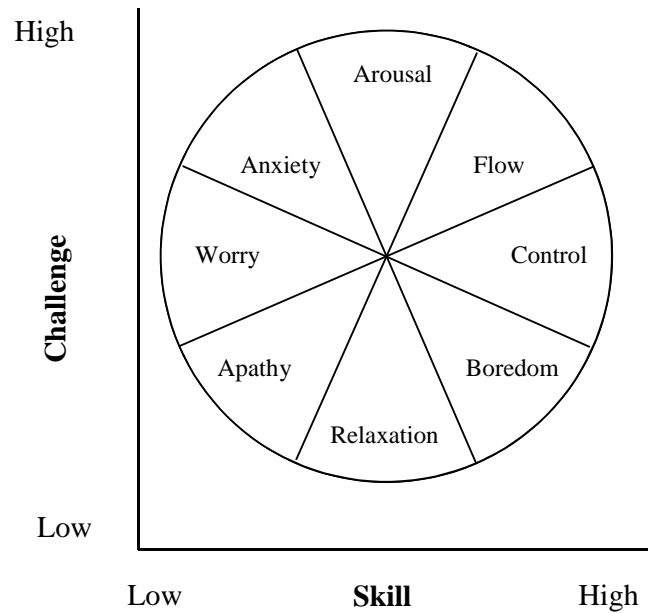
Now select the emotion which best describes how you felt during the presentation

Anxious	<input type="radio"/>
Arousal	<input type="radio"/>
Enjoyment	<input type="radio"/>
Control	<input type="radio"/>
Boredom	<input type="radio"/>
Relaxation	<input type="radio"/>
Apathy	<input type="radio"/>
Worry	<input type="radio"/>

**Next scroll the page down and answer the questions below**

**Figure 6.10 ESM questions screen**

To collect further data to provide validating evidence for the eight-channel model of flow, participants were asked to select one emotion from a list which best described how they felt during the presentation - anxious, arousal, enjoyment, control, boredom, relaxation, apathy and worry. The list was presented in the same order for each participant. The emotions in the list represented the emotions from the eight-channel model of flow which is reproduced here for ease of reference (Figure 6.11). The channel of 'Flow' was replaced with the emotion of 'Enjoyment' for the purposes of clarity and understanding, as it was considered that few participants would understand the meaning of the word 'flow' in this context, but it was likely that they would understand the meaning of 'enjoyment'. This substitution was based upon evidence described in chapter 5 where the terms 'enjoyment' and 'positivity of experience' have been used in previous studies to describe a flow experience.



**Figure 6.11 The eight-channel model of flow (Pearce, Ainley & Howard, 2005)**

Once the participant had completed the questions these results were submitted to the database, along with the participant's ID. This would ensure that the results could be matched up with the results gathered in other sections of the test.

### **Development of the pre- and post-knowledge tests**

In order to test hypothesis 1.2 "There will be a difference in the learning attainment within the four different learning situations", it was necessary to collect data about the participant's prior knowledge of the subject area as well as collecting data after they had watched the presentation. This way it would be possible to analyse the data and identify any increase in their knowledge, i.e., their learning attainment.

A set of six questions was developed to assess participant improvement in their knowledge and their understanding of the content of the presentation. Most of the questions were related to the intervention slides. Whilst many more questions could

have been included, consideration was given to the number of questions participants could be asked before getting bored and quitting the test altogether. Also, as the whole learning experience was quite a short process (it was estimated to take 10 minutes to view the entire presentation), there would be a limit as to the amount of learning actually taking place and thus a limit to the number of questions that could be posed.

The questions were reviewed by an academic psychologist to ensure they were appropriately worded. The same set of questions asked prior to the presentation would be asked again after the presentation. This would allow a direct analysis of the knowledge gained by the participant. If different questions had been asked after the presentation, with such a small number of questions it would have been difficult to identify if the participant had gained more knowledge of the subject or if they already knew the answers to these different questions prior to the presentation.

As with the ESM, five sets of randomised questions were created and each participant was presented with one of these five sets, with the questions presented in the same order before and after the presentation. Again these questions were presented in a randomised fashion to negate any effect of question order.

The question style was multiple choice, shown in Figure 6.12. The full set of questions is given in appendix H.

There are several categories of learning style. People generally fit into

- one single category
- no category
- all the categories
- one or more categories
- I really don't know

**Figure 6.12 Example multiple-choice question**

Since the purpose of the questions was to identify the level of knowledge of the participant rather than to test them, for each question an option of ‘I really don’t know’ was included. This prevented participants from being forced to select an answer if they were unsure which was the correct one. Radio buttons were used for the participant to indicate their answers so that only one answer could be selected for each question. As with the ESM questions, once the participant had completed the questions and selected to move to the next page the results were submitted and stored in the database.

### **Development of the introductory materials**

A short introductory presentation was created with the aim of explaining the procedure of the test and to allow audio equipment (where required) to be checked. Also as the test was to be conducted entirely online it would be necessary to obtain ethical consent online and this was obtained as part of the introduction before any data was recorded. The introduction was created in Flash and the test procedures were explained and example questions provided. This would serve as a short pre-training session that according to CTML principles for multimedia learning can enhance students’ learning (Moreno & Mayer, 2007). The participant’s audio equipment was then tested (where they had been randomly allocated a presentation which contained music) by playing a piece of music to the participant and allowing the participant time to adjust their audio settings and volume as required. If the situation arose that the participant did not have any audio output then there was an option for them to indicate this and they would then be randomly re-allocated to one of the presentations that did not contain any music. An ethical consent form was then displayed that explained that the participant was not being tested, but that it was the presentation which was being evaluated and that they

could choose to leave the study at any time. They then selected to accept or decline this. If they chose to decline, a thank you message was displayed and no more action was taken. If they selected to accept then the first ESM questions were displayed.

### **Experiment Pilot**

A pilot of this test was run prior to wide-scale release to ensure participants did not encounter any difficulties, either of a technical nature or in the understanding or procedure of the test. If any difficulties arose then they could be addressed and the test design re-developed as required.

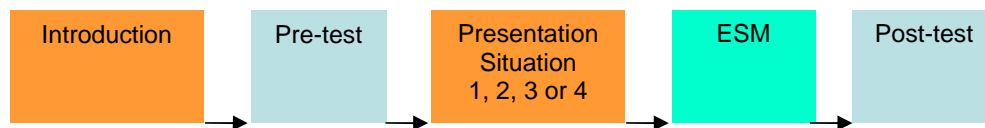
### **Sample for the pilot**

Initially a sample of 100 students from a summer access school from the University of Dundee were invited to participate in the study. Of these, 80 took part.

### **Test redesign**

The pilot test identified several issues. The first was of a technical nature, caused by some participants using quite slow machines and the presentation taking some time to load (especially the MA presentation). Participants thought there was a problem and the system was not working and abandoned the test altogether. This was rectified by including a loading indicator. This was in the form of a simple animation at the start of the Flash presentation that indicated how much of the presentation had loaded by showing a percentage along with a message asking them to 'please wait'. This ensured that there was never a blank screen presented to the participant.

The second issue raised was that many of the students were unsure about the first set of ESM questions. It was perhaps due to the wording of the questions, but they were unclear what they were answering the questions in relation to. As this created such a problem for participants and in some cases even caused a sense of anxiety because they were unclear about what to do, a decision was made to remove the first set of ESM questions altogether. Although the removal of the first ESM meant that a participant's baseline level of flow could not be established, it was apparent that leaving it in could prove to be detrimental to their state of flow by placing some participants into a state of anxiety before even starting the presentation. The test was redesigned so that after the introduction the participant would be directed straight to the pre-test and then on to the presentation. This would be followed by the ESM and finally the post-test (see Figure 6.13). Since no further issues arose from the pilot the rest of the test remained the same.



**Figure 6.13 The final test design**

## 6.6 Sampling strategy

In order to run the test there needed to be a strategy for sampling. This section describes this process, firstly by identifying the sample then by detailing how the test was run.

### Sample

Many studies into e-learning are domain specific; this can limit not only the number of recruits, but also restrict the recruits to a very specific cohort of people.

One of the benefits of using the subject of learning styles and study methods was that the content was appropriate for a very wide range of students from different subject areas. Hence students from colleges, undergraduate students from universities within the UK (including the Open University), postgraduate students from the University of Dundee and students from local secondary schools were invited to participate in the study. An invitation was also placed on a student web forum on the Internet.

University and college students were invited via their lectures. An invitation email was sent to departments of universities and also to colleges. In this email an explanation about the test was provided along with a URL link to a sample of the test. This meant that lecturers had the opportunity to examine the test and decide if they wanted to pass the invitation on to their students, without their opinions being recorded. There was also an additional section in the email for lecturers to pass on to students that briefly explained the test to the students and provided a URL link to the test.

### **Running the experiment**

Invitation emails were sent out during the end of September and beginning of October 2007. This was judged to be the most beneficial time of year for students to be provided with a presentation on learning styles and study methods, with many first-year students who could benefit from such information.

Each of the different groups of students, i.e., college, university, school and web forum, were directed to different starting pages. The content of these pages were all identical, but a hidden variable in each page allowed data about the different groups to be recorded. Each time a new participant began a test a unique ID was generated from the database for the participant and they were randomly allocated one of the four presentation situations. If after the introduction it became apparent that they did not



have audio output capabilities on their computer and they had been allocated the M or MA situations then they were re-allocated at random to either the A or N situation. The numbers of participants in each group was monitored to ensure that the groups were evenly distributed, given that it was possible that the N and A groups could contain a higher proportion of participants due to the audio issues just explained. Indeed during the period that the test was available, the numbers in the N and A groups were increasing faster than the M and MA groups. This was rectified by increasing the probability that a participant would be allocated the MA and M situations. This action led to the numbers in each group being distributed evenly whilst still maintaining a random allocation process.

The test was available for three months to allow sufficient time for lecturers to pass it on to students and for students to complete it.

This chapter has detailed the design, development and implementation of the music and animation study which formed the main experiment of this research. The next chapter details the results from this test. The findings are discussed in chapter 9.

## **CHAPTER 7**

### **RESULTS OF THE MUSIC AND ANIMATION EXPERIMENT**

The analysis strategy was to analyse data relating to the main hypotheses before drilling further down into the data to identify correlations and other significant findings. In each section a top-down approach was taken, beginning with analysis of the main data relating to the research questions and followed by the data being analysed in greater detail, examining other data that had been collected. Various test were used during the analysis of the data, such as Pearson correlations, independent t-tests and ANOVA tests. ANOVA tests were used where multiple groups were to be compared. The first section of this chapter discusses the background results of the music and animation study, followed by the results pertaining to the learning attainment. The third section examines the results relating to the ability to enter a state of flow by detailing the ESM results. Sections four and five provide results relating to the validation of the eight-channel model of flow and the skill and challenge constructs of flow. The remaining sections in this chapter provide results from deeper analysis of the data. Results discussed in more detail in later chapters are numbered for reference purposes.

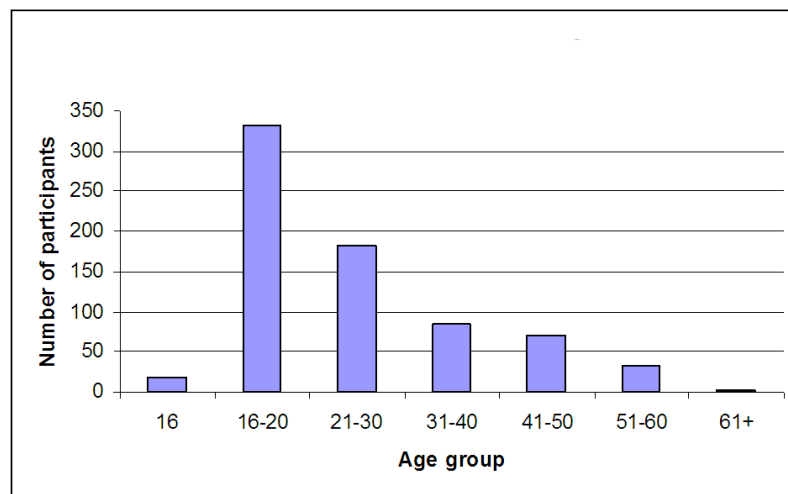
#### **7.1 Background results about the participants**

A total of 722 participants completed the test. Of these 187 participants viewed the music and animation (MA) presentation, 167 participants viewed the Music (M), 192 viewed the Animation (A) and 176 viewed the presentation without music or animation (N). Homogeneity was seen between all groups with regards to gender and age. A slight

skew was seen in the number of college students allocated to the musical groups, with fewer in these groups than in the non-musical groups.

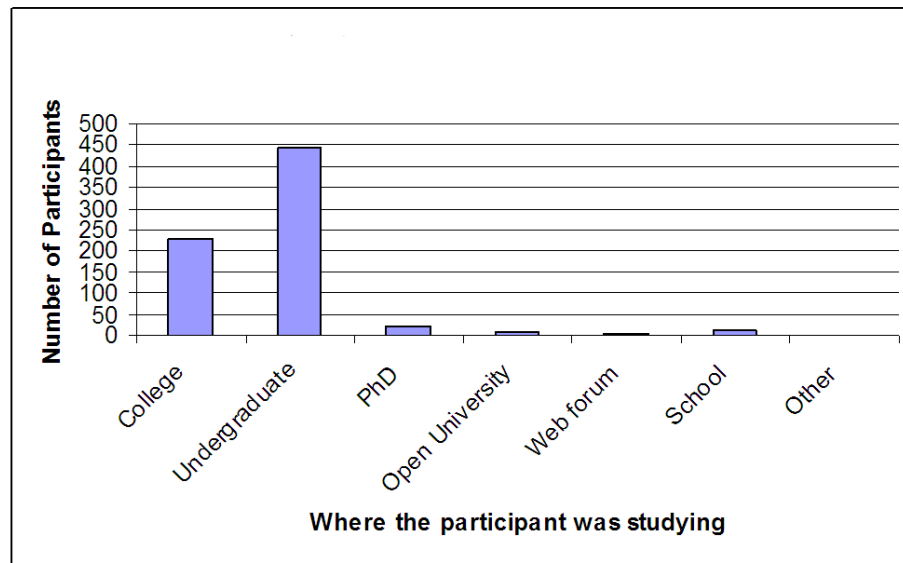
Of the 722 participants there were 254 male and 452 female, with 16 not indicating their gender.

The majority of participants were aged between 16 to 30 years old. The largest group was the 16-20 age group (Figure 7.1).



**Figure 7.1 The age ranges of the participants**

Figure 7.2 shows that the majority of the participants were either studying at college or university, being 228 and 442 participants respectively. There were 21 participants who were studying for a PhD, 15 who were at school, eight from the Open University, six from the web forum and two studying elsewhere.



**Figure 7.2 The number of participants studying in different areas**

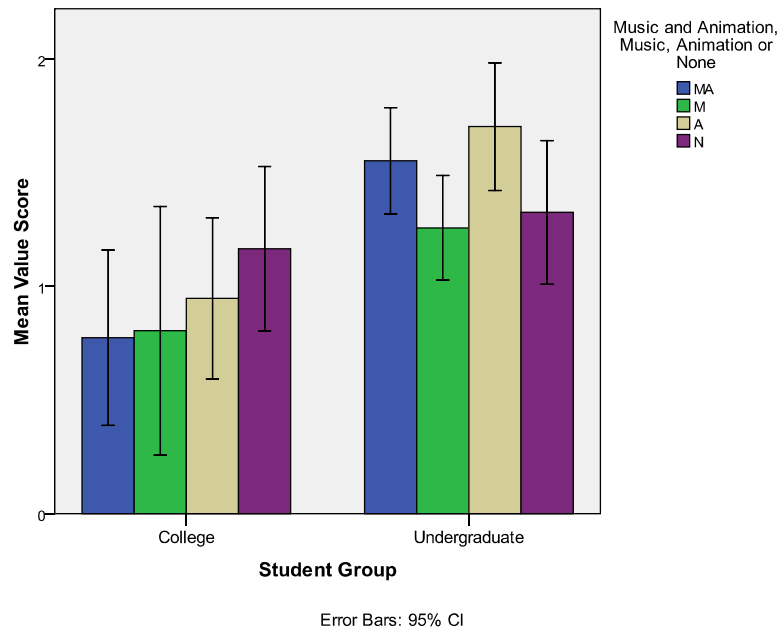
## 7.2 The learning attainment results

One aim of this research was to identify if the inclusion of music and/or animation in an online learning environment would have any impact upon the learning attainment of participants. A *value score* was created by subtracting the pre-test score from the post-test score, giving a score that reflected the amount the participants had learned. Any differences in the value score between different learning situations was initially analysed, the results from this were used to assess hypothesis 1, and then the value score was analysed against other primary data, such as participant age, their type of study (i.e., college or undergraduate, etc) and the amount of time they took to view the presentation.

No significant difference in the value score was seen between the different learning situations (result A1).

No significant differences or correlations were seen between the value score and the age or gender of the participants, the emotions selected, ESM total or the time of day the test was taken.

A significant difference was found in the value score between the groups of college students and undergraduates (Figure 7.3 and Table 7.1).



**Figure 7.3 Value scores for student groups in the different situations**

**Table 7.1 The number of participants in each group**

Learning Situation	College Students	Undergraduate Students
MA	49	130
M	36	116
A	77	98
N	66	98

Not only was a significant difference observed over all of the situations combined ( $t(668) = -4.346, p < .001$ ), but also within the situations of MA ( $t(177) = -3.450, p = .001$ ) and A ( $t(173) = -3.367, p = .001$ ). No significant difference was found in the N or M situations. In each case where a significant difference was seen, the undergraduates had a higher value score than the college students (result A2).

A Pearson correlation showed that there was a significant positive correlation between total time taken to complete the presentations and the value score ( $r = .139, p < .001, n = 722$ ). A similar significant trend was identified for two of the situations when analysed separately, with both M and N showing positive correlations at  $p = 0.33$  and  $0.15$  respectively (result A3).

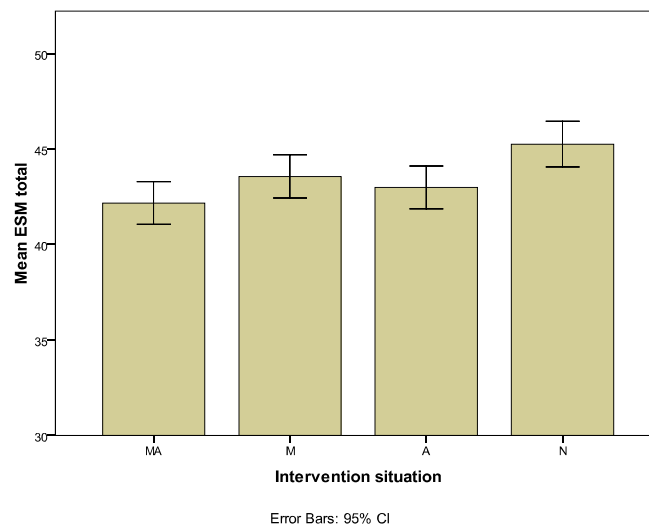
There was also a significant positive correlation between the total number of revisits to previous slides and the value score ( $r = .119, p = .001, n = 720$ ). When the different situations were analysed separately, only the N ( $p = .001$ ) and the MA ( $p = .010$ ) situations showed a positive significance, while the A and M situations did not show any significance (result A4).

Furthermore, there was a correlation between the perceived level of challenge and skill with the value score. The higher the perceived level of skill, the higher the value score ( $r = 0.93, p = .012, n = 722$ ). Conversely, the higher the level of perceived challenge, the lower the value score ( $r = .086, p = .020, n = 722$ ) (result A5).

### 7.3 The ESM results

The results from the 14 questions about the participants' state of flow were added together to provide a total score for the potential to enter a state of flow. This was called the ESM total, and the greater the total the higher the potential to enter a state of flow. This provided data that was analysed to obtain a result for hypothesis 1.1, "There will be a difference in the learner's ability to enter a state of flow between the four different learning situations".

The ESM total score varied significantly according to the presentation situation when a one way ANOVA test was applied as there were multiple groups being compared ( $F(3,642)=5.136$ ,  $p = .002$ ). MA produced a significantly lower score than N ( $p=.001$ ) as did the A situation ( $p=.032$ ). There were no significant differences between the other situations (Figure 7.4) (result B1).



**Figure 7.4 Comparison of the mean ESM total between the situations**

### **The ESM total and the emotions**

Further analysis was carried out into the emotions the participant selected and their ESM total. The ESM total varied significantly depending upon the emotion the participant selected ( $F(7,617) = 26.84, p < .001$ ). This is shown in Figure 7.5. Table 7.2 shows the frequency of each of the emotions selected (result B2). In particular the emotions detailed below show the significant differences.

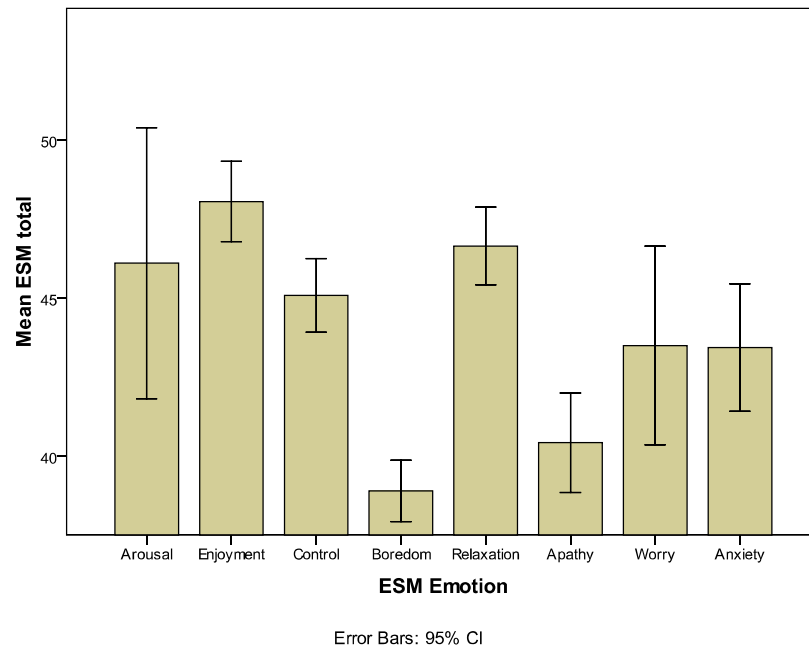
For Arousal the ESM total was significantly higher than for Boredom ( $p < .001$ ) and Apathy ( $p = .024$ ).

For Enjoyment the ESM total was significantly higher than for Control ( $p = .042$ ), Boredom ( $p < .001$ ), Apathy ( $p < .001$ ) and Anxiety ( $p = .003$ ).

For Control the ESM total was significantly higher than for Boredom ( $p < .001$ ) and Apathy ( $p < .001$ ).

For Relaxation the ESM total was significantly higher than for Boredom ( $p < .001$ ) and Apathy ( $p < .001$ ).





**Figure 7.5 The selected emotions and the mean ESM total**

**Table 7.2 The frequency of emotions in Figure 7.5**

Emotion	Frequency
Boredom	207
Relaxation	115
Control	109
Enjoyment	107
Apathy	67
Anxiety	47
Worry	23
Arousal	22

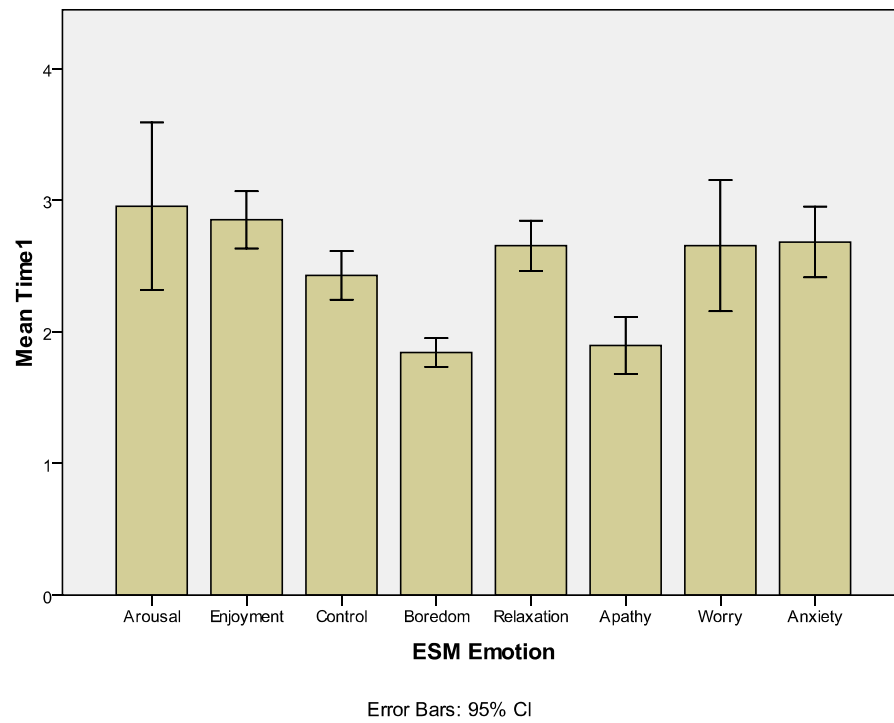
A significant correlation was found between the ESM total and the perceived level of challenge. This is described later in section 7.5.

No other significant results were found relating to the ESM total when analysed with the other data of age, gender, time taken, level of skill, self-reported MBTI, value score, time of day or number of revisits.

### **The individual ESM questions and the emotions**

All but one of the ESM questions showed a significant relationship between the score for the ESM question and the emotions selected (see Table 7.3). The only ESM question that did not show a difference was for the feedback construct FDBK2 (“I knew how well I was proceeding”). A list of ESM question codes is also provided in Table 7.3.

The first question for transformation of time/time distortion, Time1 (“I was so focused that I completely lost track of time”), was the question with the most number of significant differences between the emotions. Figure 7.6 shows the emotions selected plotted against the mean score for Time1. The full set of figures can be found in appendix I. The trend for each of the other ESM questions followed the same pattern as seen in Figure 7.5. Generally the positive emotions of ‘Arousal’, ‘Enjoyment’, ‘Control’ and ‘Relaxation’, produced the highest scores for the ESM questions, and the more negative emotions of ‘Boredom’ and ‘Apathy’ produced the lowest ESM question scores. This shows a good correlation between the results for the flow constructs and the participant’s reported emotions (result B3).



**Figure 7.6 The emotions selected and the mean scores for ‘Time1’**

Table 7.3 Differences between the ESM question and emotions selected

Code	Flow construct	ESM question	Results of the variation in the emotions selected using an ANOVA test	Number of significant differences between emotions
Goal1	Clear goals	I knew clearly what I was supposed to do.	( $f(7, 686) = 2.837, p=.006$ )	1
Goal2	Clear goals	I knew where I was and knew where to go next and what to do next.	( $f(7, 685) = 2.102, p=.001$ )	3
Concen1	Concentration	I was absorbed intensely in the activity.	( $f(7, 682) = 24.888, p<.001$ )	9
Concen2	Concentration	I was concentrating fully on the activity.	( $f(7, 684) = 13.995, p<.001$ )	9
Focus1	Focus	I was aware of distractions ( <i>scale was reversed</i> )	( $f(7, 684) = 5.148, p<.001$ )	2
Focus2	Focus	I thought about other things ( <i>scale was reversed</i> )	( $f(7, 684) = 13.965, p<.001$ )	8
CTRL1	Control	I felt frustrated. ( <i>scale was reversed</i> )	( $f(7, 684) = 20.098, p<.001$ )	11
CTRL2	Control	I always felt in control.	( $f(7, 682) = 7.531, p<.001$ )	7
Tela1	Loss of self-consciousness / <del>telepresence</del>	I felt that during the presentation I was more in the "computer world" than the "real world" around me.	( $f(7, 682) = 4.124, p<.001$ )	4
Tela2	Loss of self-consciousness / <del>telepresence</del>	During the presentation I forgot about my immediate surroundings.	( $f(7, 685) = 11.714, p<.001$ )	6
Time1	Transformation of time / time distortion	I was so focused that I completely lost track of time.	( $f(7, 685) = 18.192, p<.001$ )	13
Time2	Transformation of time / time distortion	Time went faster than I thought and I did not even sense it.	( $f(7, 686) = 11.336, p<.001$ )	6
FDBK1	Feedback	I got direct clues (feedback) as to how well I was doing.	( $f(7, 683) = 2.128, p=.028$ )	1
FDBK2	Feedback	I knew how well I was proceeding.	( $f(7, 684) = 1.785, p=.087$ )	0

### **The individual ESM questions and the situations**

The data was analysed using the separate ESM questions to gain a deeper insight into the different constructs of flow. These results were used to identify if hypothesis 2 “The inclusion of music and animation will affect some of the flow constructs, but not all”. The findings are discussed further in chapter 9.

This analysis revealed that the results for the statement CTRL1 (“I felt frustrated”) varied significantly according to the situation. ( $F(3,711) = 10.561, p < .001$ ). Those in the M situation were significantly less frustrated than those in the MA ( $p = .011$ ) or A ( $p = .021$ ) situations. Similarly, those in the N situation were significantly less frustrated than those in the MA or A situation with the results for both being  $p < .001$  (result B4).

The statement CTRL2 (“I always felt in control”) showed a significant difference ( $F(3,679) = 3.363, p = .018$ ), with those in the N situation perceiving that they had more control than those in the A situation ( $p = .012$ ) (result B5).

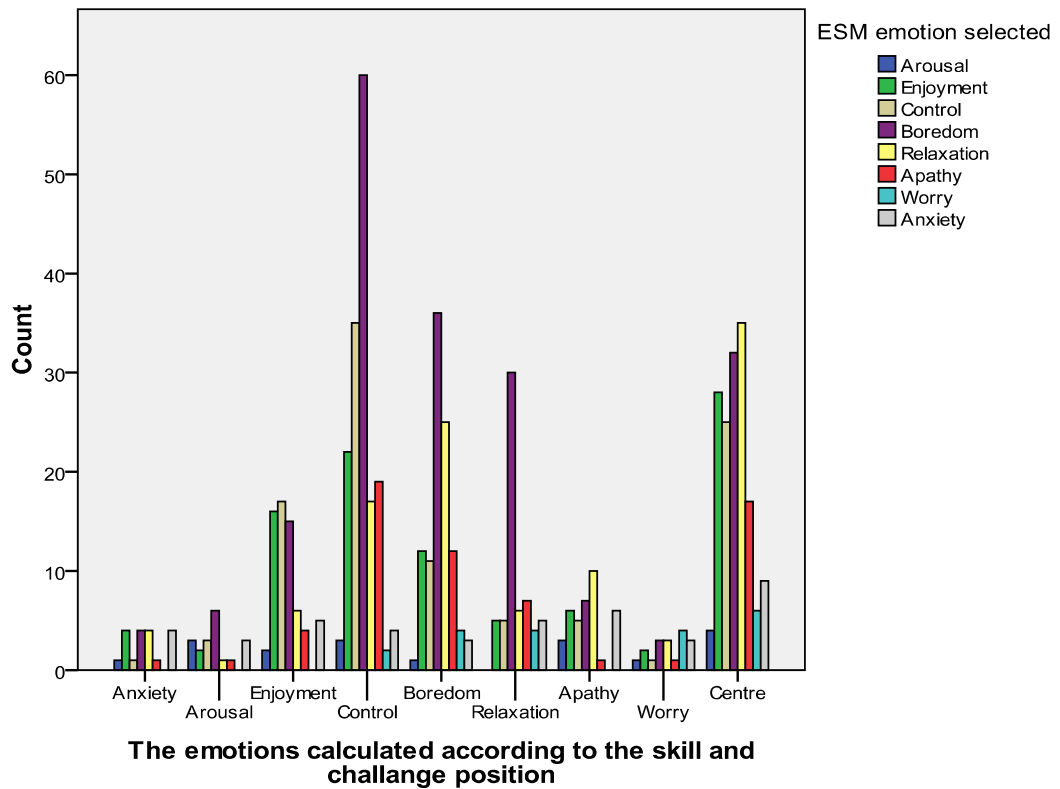
Significant differences were also seen between the situations for the statements Concen1 (“I was absorbed intensely in activity”) and Time2 (“Time went faster than I thought and I did not even sense it”) showing ( $F(3,708) = 3.201, p = .023$ ) and ( $F(3,713) = 2.863, p = .036$ ) respectively. The people in the N situation were more absorbed in the activity than people in the MA situation ( $p = .027$ ), with the N situation causing a greater time distortion than the MA situation ( $p = .04$ ) (result B6).

There were no other significant differences found between the four situations and the ESM questions.

#### **7.4 Validation of the eight-channel model of flow**

The design of the test allowed data to be collected that could be analysed to provide validation for the eight-channel model of flow as described in section 6.9. Specific emotions were selected by the participant, and the perceived levels of skill and challenge were indicated by selecting a position within the skill/challenge graph. It was this position that was used to calculate which of the eight channels the participant was likely to be experiencing. The results from the calculated channel and the specific emotion selected were then compared. The greater the match between the calculated channel and the specific emotion, the greater the level of validation for the model this would provide.

Analysis of the selected emotions and the calculated emotions showed no significant correlation between the two sets of emotions (Figure 7.7) (result C1).



**Figure 7.7 The calculated emotions and the emotions that were selected**

However, an ANOVA test revealed that there were significant differences in the selection of the emotions by the participants and the selected skill levels ( $F(7, 689) = 4.5, p < .001$ ) (result C2). Significant differences were also seen in the emotions selected and the level of challenge ( $F(7, 689) = 8.5, p < .001$ ) (result C3). Differences between the individual emotions are shown in Tables 7.4 and 7.5, while the overall mean positions of the emotions can be seen in Figure 7.8. These results will be returned to and discussed in more detail in chapter 9.

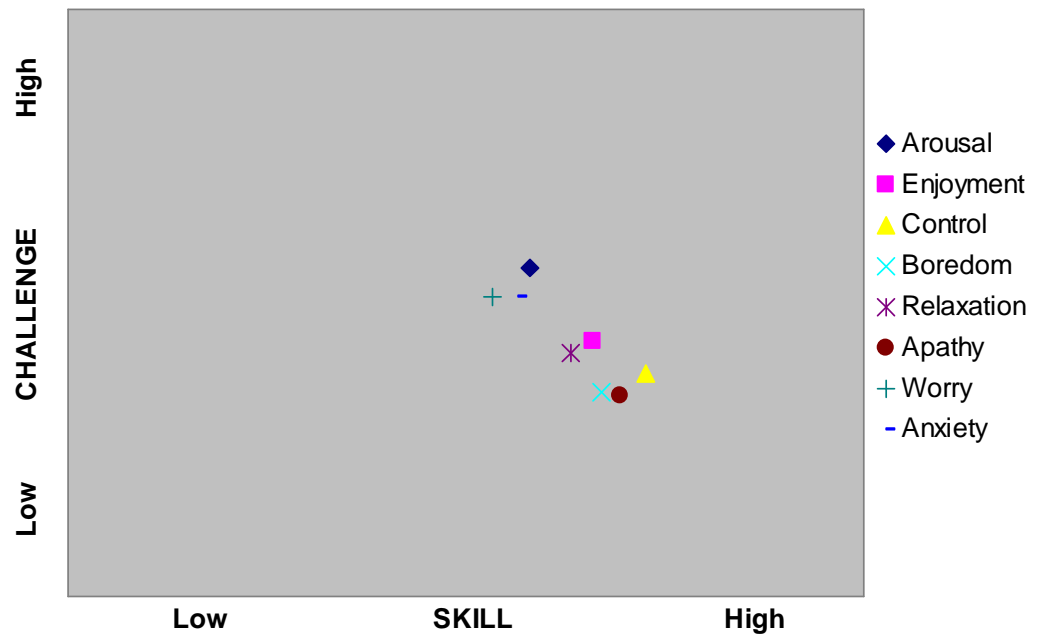
**Table 7.4 Differences between the emotions on the challenge axis**

Significant differences between the selected emotions		Level of significance
Arousal	Control	p=.003
Arousal	Boredom	p<.001
Arousal	Relaxation	p=.043
Arousal	Apathy	p=.001
Enjoy	Boredom	p=.008
Control	Anxiety	p=.004
Boredom	Worry	p=.006
Boredom	Anxiety	p<.001
Apathy	Worry	p=.025

**Table 7.5 Differences between the emotions on the skill axis**

Significant differences between the selected emotions		Level of significance
Control	Relaxation	p=.048
Control	Worry	p=.005
Control	Anxiety	p=.001





**Figure 7.8 Position of emotions against the level of skill and challenge**

Whilst analysing the emotions against other data, such as the age and gender of participants and time of day the test was taken, etc., only one further significant finding was observed. This related to the total amount of time spent viewing the presentation, and this varied significantly according to the emotion selected by the participant ( $F(7,689) = 2.369, p=.021, N=696$ ). The amount of time taken was significantly higher for Arousal than for both Boredom ( $p=.008$ ) and Apathy ( $p=.021$ ) (result C4).

### 7.5 Skill and challenge correlations

The flow constructs of skill and challenge were analysed separately to the other constructs, as not only were they measured in a different manner but are often considered to be somewhat special constructs of flow (as discussed in chapter 5).

The overall effect of the perceived level of skill and challenge was analysed, with skill and challenge then analysed against the other constructs of flow. This was done by analysing correlations between skill/challenge and the scores for the individual ESM questions. The aim of this analysis was to show how the constructs of challenge and skill might interact with the other constructs of flow, and to enable the identification of the key components. The data was then analysed in more detail to identify any correlations between other variables within the data and the skill and challenge components.

With all of the intervention situations being analysed together a negative correlation between the challenge axis of the skill / challenge graph and the ESM total was seen ( $r = -.185$ ,  $p < .001$ ). This indicated that the higher the perceived level of challenge was, the higher the ESM total (result D1). A similar trend was seen when the results were divided into the four intervention situations with MA ( $r = -.156$ ,  $p = .041$ ), A ( $r = -.198$ ,  $p = .009$ ) and N ( $r = -.255$ ,  $p = .001$ ) all showing a negative correlation indicating the same as above. The M situation did not show any significance.

No significant correlation was found between the skill axis and the ESM total (result D2).

### **Individual ESM questions and the axes of skill and challenge**

Further analysis of the individual ESM questions against the challenge and skill axes revealed several significant correlations, and these are shown in Tables 7.6 and 7.7 respectively.

**Table 7.6 Correlations between the challenge axis and the ESM questions**

ESM question code	The r value	The p value
Concen1	-.270**	<.001
Concen2	-.133**	<.001
Time1	-.247**	<.001
Time2	-.163**	<.001
FDBK1	-.166**	<.001
Focus2	-.199**	.001
Tele2	-.122**	.001
Tele1	-.088*	.018
CTRL2	-.067	.080
FDBK2	-.057	.131
Goal1	.054	.146
CTRL1	-.054	.148
Focus1	-.013	.719
Goal2	-.008	.829

(\*\* Correlation is significant at the level 0.01. \*Correlation is significant at the level 0.05)

These results indicate that the perceived levels of challenge do not have a significant correlation with the flow constructs of *clear goals* or *control*; however, there is a small correlation with the constructs of *focus* and *feedback*. A strong correlation was seen between the perceived level of challenge and the constructs of *concentration*, *loss of self-consciousness/telepresence* and *transformation of time/time distortion*. In each instance a negative correlation indicated that the higher the level of perceived challenge, the more participants would feel focused, would understand more clearly what they were doing and where they were going (feedback construct), feel more in control, experience a greater loss of self-consciousness, and also lose track of time more (result D3).

**Table 7.7 Correlations between the skill axis and the ESM questions**

ESM question code	The r value	The p value
Time1	-.127**	.001
Concen1	-.117**	.002
Goal2	.097**	.010
CTRL2	.096*	.012
FDBK1	-.090*	.017
Goal1	.084*	.024
Time2	-.075*	.044
CTRL1	.071	.057
FDBK2	.058	.124
Focus1	.052	.166
Focus2	-.030	.418
Tele2	-.025	.499
Tele1	-.12	.567
Concen2	-.012	.750

(\*\* Correlation is significant at the level 0.01. \*Correlation is significant at the level 0.05)

The results indicated that the perceived level of skill does not have a significant correlation with the flow constructs of *focus* and *loss of self-consciousness/telepresence*. There was a small positive correlation between the skill level and the construct of *control*, indicating that the higher the level of skill the greater the sense of control. There was also a small correlation between the skill level and the constructs of *concentration* and *feedback*, but this was a negative effect. This meant that the higher the level of perceived skill the lower the level of concentration and feedback. The strongest correlations were seen between the perceived skill and the constructs of *clear goals* and *transformation of time/time distortion*. The correlation with *clear goals* was a positive one meaning that the higher the level of skill the clearer the goals were. However, the correlation between the transformation of time and skill level was a

negative one, meaning the higher the level of skill the less likely the person would be to lose track of time (result D4).

The strongest of the effects of challenge and skill was seen with the ESM questions Concen1 “I was absorbed intensely in the activity” and Time1 “I was so focused that I completely lost track of time”.

Analysing each of the intervention situations separately for these two particular questions revealed that there was a significant negative correlation for each of the situations (Table 7.8).

**Table 7.8 ESM question analysis against the challenge axis within the individual situations**

ESM Question	Presentation situation	Result
Concen1	MA	$r = -.323, p < .001$
Concen1	A	$r = -.270, p < .001$
Time1	N	$r = -.287, p < .001$
Time1	MA	$r = -.241, p = .001$
Time1	A	$r = -.236, p = .001$
Concen1	N	$r = -.248, p = .001$
Time1	M	$r = -.232, p = .003$
Concen1	M	$r = -.226, p = .004$

In each situation for the ESM question Concen1 the higher the participant’s perceived level of challenge, the more likely they were to be absorbed in the activity. Likewise, for each situation for the ESM question Time1 the higher the perceived level of challenge the more likely that the participant would lose track of time (result D5).

### **Further results for the axes of skill and challenge**

Challenge and skill data were analysed for any significant effects with the following elements:

- ESM Emotion
- Education type (i.e., college, undergraduate)
- Total time taken to view the presentation
- Time the test was taken
- The total number of revisits to the slides
- Value score
- Self-reported MBTI perceptions
- Self-reported Gardner's Multiple Intelligences (GMI) perceptions
- Gender
- Age
- Learning situation (MA, M, A, N)

Significant findings were found in the skill axis in the value score, self-reported MBTI perceptions and within the self-reported GMI perceptions Verbal/Linguistic, Logical/Mathematical, Musical/Rhythmic and Intrapersonal. No other significant correlations were seen.

The level of skill reported had a relationship to the MBTI the participant selected ( $F(15, 623) = 2.05, p < .011$ ). In particular, those who selected the axis of Extrovert, Intuition, Feeling and Judging (ENFJ) indicated themselves to be less skilled than those who selected the axis of Introvert, Sensing, Thinking and Perceiving (ISTP) (result D6).

For the challenge axis significant findings were seen with the value score, GMI Logical/Mathematical and Intrapersonal options. No other significant correlations were seen.

The value score results were discussed earlier (see result A5).

The results for the GMI are given in Table 7.9.

**Table 7.9 Challenge, skill and Gardner's Multiple Intelligences**

Skill / Challenge Axis	Gardner's Multiple Intelligences	Result
Skill	Intrapersonal	$t(720) = -4.663, p < .001$
Challenge	Intrapersonal	$t(720) = -3.769, p < .001$
Skill	Musical/rhythmical	$t(720) = -3.374, p = .001$
Skill	Logical/Mathematical	$t(720) = -2.501, p = .013$
Skill	Verbal/Linguistic	$t(720) = -2.105, p = .036$
Challenge	Logical/Mathematical	$t(720) = -2.057, p = .040$

For each result shown in Table 7.9, those who selected the indicated GMI also felt more skilled with lower levels of challenge than those who did not select it (result D7).

## 7.6 Further differences between the four situations

The data was further analysed to identify any additional differences between the four learning situations. Some differences have already been reported in earlier sections of this chapter (see results A2, A3, A4, B1, B2, B3, B5, D1, D3). No significant differences were seen in the level of skill or challenge perceived by the participant or the total number of revisits to previous slides between the situations. However, four of the ESM questions showed a significant difference between the situations, being Concen1 ( $F(3, 708) = 3.201, p = .023$ ), CTRL1 ( $F(3, 711) = 10.561, p < .001$ ),

CTRL2( $F(3, 679) = 3.363, p = .018$ ) and Time2( $F(3, 713) = 2.863, p = .036$ ) (Result E1). None of the remaining ESM questions showed any significant differences between the situations.

**Table 7.10 Differences between the situations and the ESM questions**

ESM question	Difference between situations	Result
CTRL1	N and MA	$p < .001$
CTRL1	N and A	$p < .001$
CTRL1	M and MA	$p = .011$
CTRL2	N and A	$p = .012$
CTRL1	M and A	$p = .021$
Concen1	N and A	$p = .027$
Time2	N and MA	$P = .040$

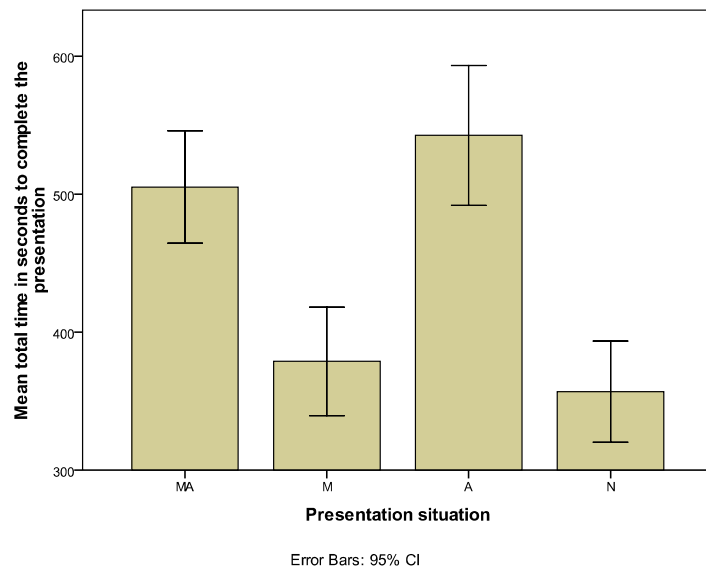
Table 7.10 shows which of the situations produced the higher scores for these ESM questions. In each instance the N and the M situation produced a higher score than MA or A.

Significant differences in the total time taken to view the presentation were found between the four situations when an ANOVA test was applied ( $F(3, 721) = 18.1, p < .001$ ), as shown in Figure 7.9 (result E2).

MA took longer than M ( $p < .001$ ) and N ( $p < .001$ ), while A also took longer than M ( $p < .001$ ) and N ( $p < .001$ ).

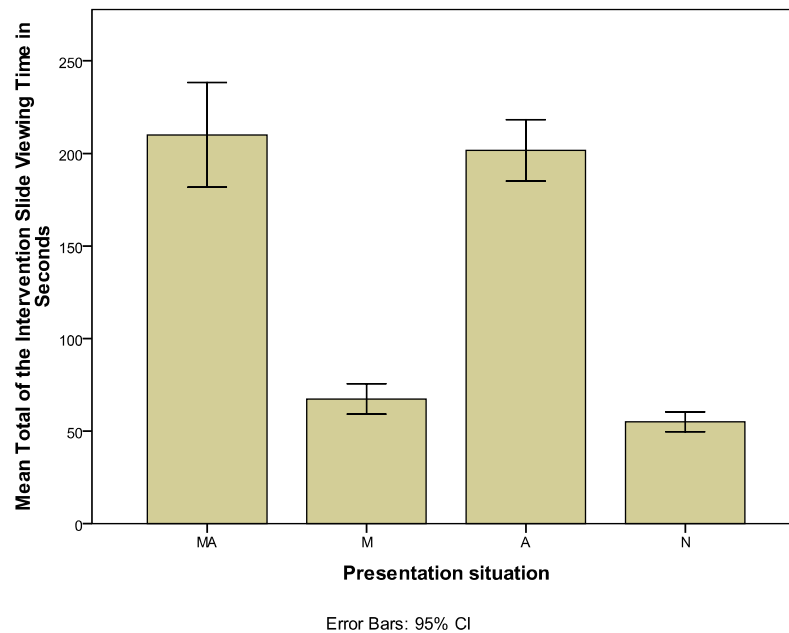
There was no difference between M and N ( $P = 1$ ), or MA and A ( $P = 1$ )





**Figure 7.9 The mean total time taken to view the slides**

The mean time taken to view the intervention slides in the presentations (Figure 7.10), varied significantly according to the presentation situation ( $F(3,718) = 86.8, p < .001$ ) (result E3). In each instance, MA and A took significantly longer than M and N when tested using a one way ANOVA test with  $p < .001$ .



**Figure 7.10 The mean time taken to view all the intervention slides**

### **7.7 Differences between the age groups and the time taken to view the presentation**

Analysis was carried out to identify if the age of the participant had any significant effect upon the results. The only significant finding was that the total time taken to complete the presentation varied significantly according to the age of the participant ( $F(6,715) = 3.023, p=.006$ ), with the 16-20 year old age group taking significantly less time than the 21-30 year old group ( $p=.003$ ) (result F1).

A general trend for the amount of time taken to increase as age increased was seen. However, there were not enough participants in the other groups to indicate any statistical significance.

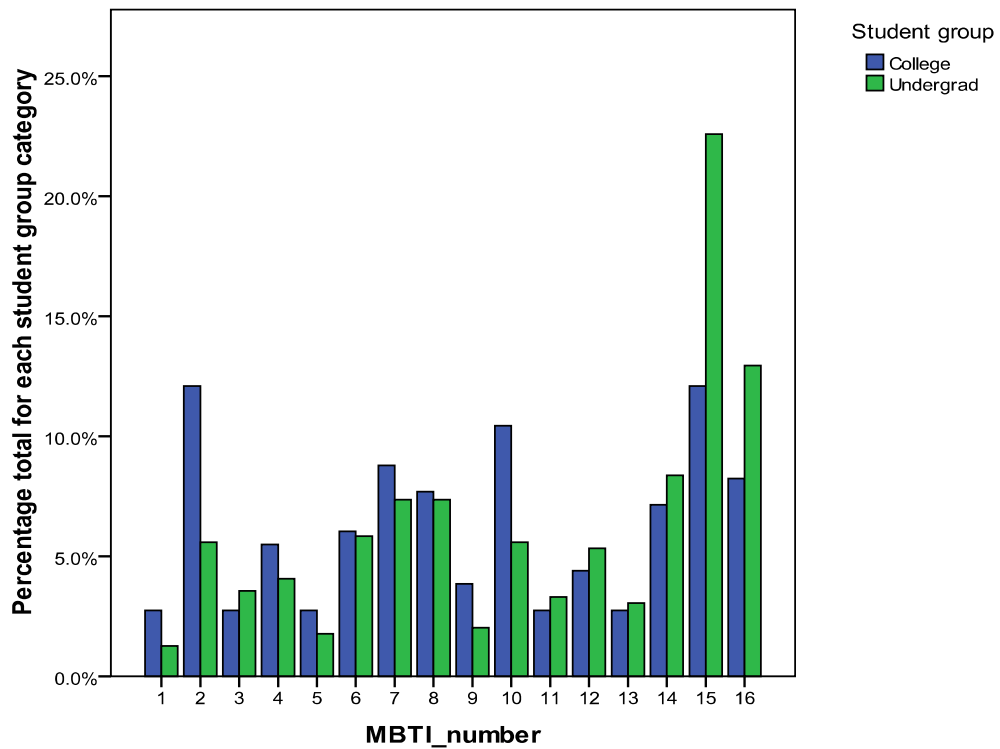
### **7.8 Differences between the student groups**

It was discussed earlier that undergraduates produced higher value scores than college students (see result A2). Several further differences between these two groups were seen, in particular analysis of the data using an independent t-test showed significant differences in the time of day at which they took the test ( $t(668) = -8.927, p < .001$ ). The peak number of college students took the test at approximately 11am, with a second smaller peak seen at around 2pm. For the undergraduate students the times for taking the test were steadier, and generally between the hours of 8am and 10pm (result G1).

A significant difference was seen in the self-reported learning styles between the groups of college and undergraduate students ( $t(574) = -4.021, p<.001$ ) (result G2). Evident differences exist in the selection of the MBTI, with more college students selecting MBTI number 2 and more undergraduate students selecting MBTI number 15. The key to the MBTI index is given in Table 7.11.

**Table 7.11 The key to the MBTI index**

<b>MBTI Number</b>	<b>MBTI preference scale: Extrovert (E)/ Introvert (I) Sensing (S)/ Intuition (N) Thinking (T)/ Feeling (F) Judging (J)/ Perceiving (P)</b>
1	ENFJ
2	ENFP
3	ENTJ
4	ENTP
5	ESFJ
6	ESFP
7	ESTJ
8	ESTP
9	INFJ
10	INFP
11	INTJ
12	INTP
13	ISFJ
14	ISFP
15	ISTJ
16	ISTP



**Figure 7.11 Percentage of college and undergraduate students self-reporting their MBTI**

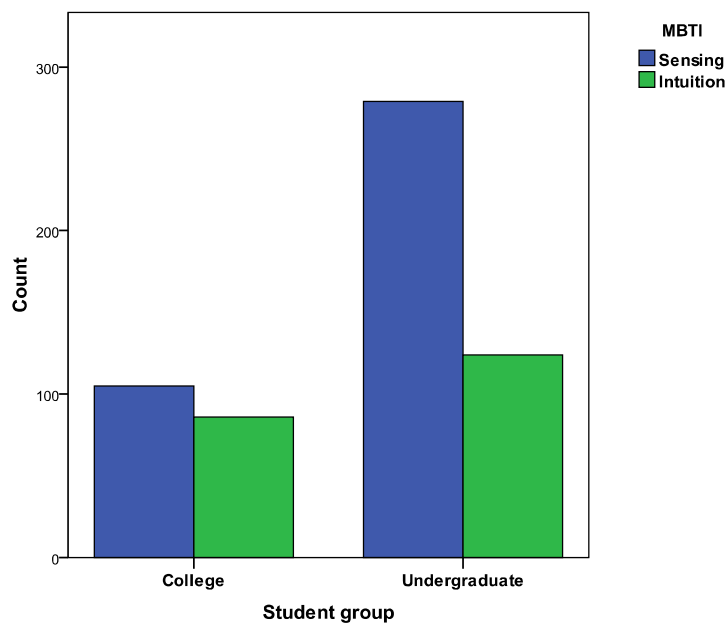
Additional analysis of the individual axis of the self-reported MBTI showed some significant differences between the student groups (result G3).

For the axis of Introvert/Extrovert a significant difference was found between the college and undergraduate groups ( $t(602) = 2.947, p = .004$ ). Undergraduates were more likely to select 'Introvert' than 'Extrovert', yet little difference was seen between the two for college students.

Figure 7.12 shows that for the axis of 'Sensing/Intuition' there was little difference amongst the college students; however, the undergraduates were more likely to select 'Sensing' than 'Intuition'. Again this difference between the two student groups was significant ( $t(592) = 3.33, p = .001$ ).

Similarly, for the selection 'Feeling/Thinking' there was little difference amongst the college students, but the undergraduate students were more likely to select 'Thinking' over 'Feeling'. However, there was a significant difference between these two groups ( $t(612) = 3.207, p = .001$ ).

No significant differences were seen for the final axis of 'Judging/Perceiving' between the groups ( $t(589) = 1.248, p = .213$ ).



**Figure 7.12 The number of students selecting MBTI Intuition or Sensing**

There was also a significant difference found in the selection of Gardner's Multiple Intelligences Logical/Mathematical and Intrapersonal between the student groups. A significantly higher proportion of undergraduate students selected Logical/Mathematical ( $t(668) = -3.91, p < .001$ ) and Intrapersonal ( $t(668) = -4.106, p < .001$ ) than college students (result G4).

## 7.9 Further results for the self-reported learning styles

Data about the participant's perceptions of their learning styles along the MBTI axes and GMI were recorded. These particular learning styles were used as they formed part of the content of the presentation and as such meant the participant was well informed about these learning styles. Analysis of the self-reported learning styles was carried out in order to identify if a participant's perception of their learning styles had any effect upon their emotions, learning attainment or any other aspects of the learning situation. It should be pointed out that these results indicate the participant's perceptions of their learning styles, since they are simply selecting the learning style category which best matched their perceptions of themselves. Several results relating to the self-reported learning styles have already been reported; however, further analysis was carried out examining each of the axes of the self-reported MBTI and Gardner's Multiple Intelligences against the various data and significant findings are reported next.

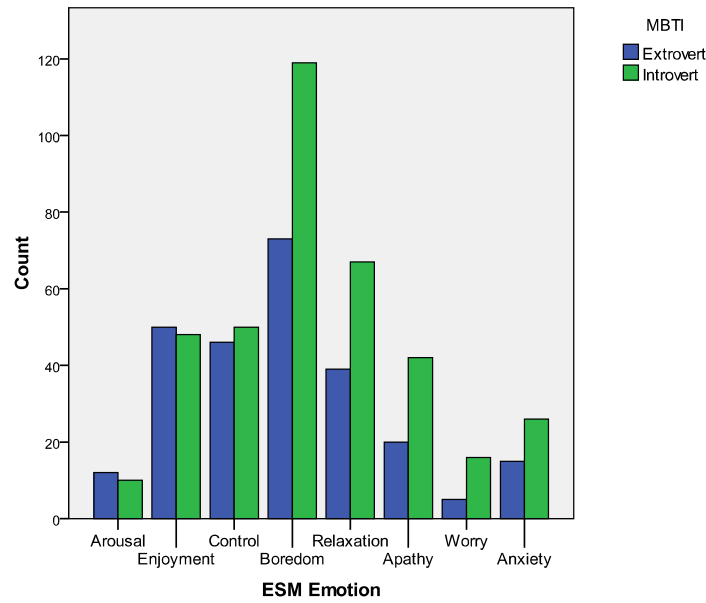
Firstly, when the MBTI axes were analysed, an independent t-test showed that the value score varied significantly according to whether participants perceived themselves to be Sensing or Intuitive ( $t(641) = 2.5, p = .011$ ). Those who considered themselves to be Sensing scored higher than those who selected Intuitive.

Similar results were seen for Gardner's Multiple Intelligences, with participants who classed themselves as Intrapersonal scoring significantly higher on the value score than those who did not select this category ( $t(720) = -3.6, p < .001$ ). Participants who perceived themselves to be in the category of Logical/ Mathematical also scored higher on the value score than those who did not select this category ( $t(720) = -2.8, p = .005$ ) (result H1).

Participants who selected Body and Motion from Gardner's Multiple Intelligences scored significantly higher in the ESM than those who did not select this category ( $t(432) = 2.5, p=.015$ ) (result H2). However, there was no significant difference in the value score. These results are discussed further in chapter 9 with regards to hypothesis 3.2.

Finally, the participants who selected both Music/Rhythm ( $t(718) = -2.6, p = .011$ ) and Intrapersonal ( $t(718) = -2.1, p = .037$ ) had a significantly higher number of revisits to the intervention slides than those who did not select these categories (result H3).

There was no significant difference in any of the other individual elements within the self-reported GMI or in the self-reported MBTI for value score, total of ESM or total number of revisits to the slides. There were also no significant findings when the data was analysed across the four different learning situations. However, a significant difference was found when an independent t-test was used to analyse the emotions selected from the list in the ESM question page. Figure 7.13 shows the tendency for participants who considered themselves as introverts to select more negative emotions than those who considered themselves as extroverts ( $t(636) = -3.238, p = .001$ ) (result H4).

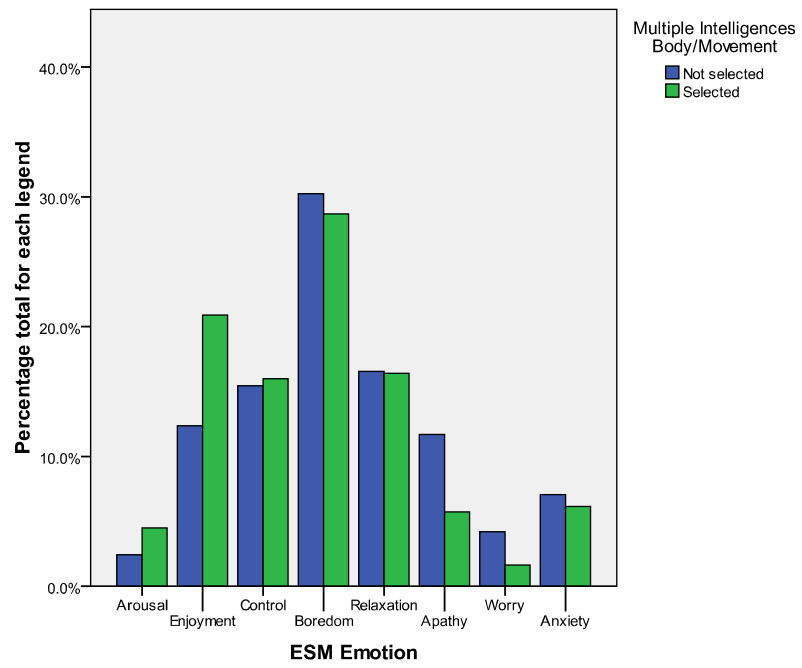


**Figure 7.13 Comparison of the emotions selected by extroverts and introverts**

Those who selected Gardner's Multiple Intelligences Body/Movement also showed a significant difference in the emotions they selected ( $t(695) = 3.490$ ,  $p = .001$ ). In particular, those who selected 'Body/Movement' selected enjoyment more often than those who did not select 'Body/Movement'. Those who selected 'Body/Movement' also selected the negative emotions of 'Apathy', 'Worry' and 'Anxiety' less often (see Figure 7.14) (result H5). Likewise, those who selected 'Musical/Rhythmical' also showed a significant difference in the emotions they selected than those who did not select 'Musical/Rhythmical' ( $t(695) = 2.727$ ,  $p=.007$ ). A similar trend was found towards more positive emotions, such as 'Arousal' and 'Enjoyment', being chosen by those who selected 'Musical/Rhythmical', with the more negative emotions of 'Apathy', 'Worry' and 'Anxiety' being selected by those who did not categorise themselves as 'Musical/Rhythmical' (result H6).

None of the other categories of self-reported GMI or self-reported MBTI showed any significant differences in the emotions selected.





**Figure 7.14 Comparison of the emotions selected and GMI Body/Movement**

## **CHAPTER 8**

### **VALIDATION TESTS**

Having completed the main experiment of this research, the music and animation study, and analysed the results, it was apparent that there were significant differences between presentation situations with regards to participant perception of both their state of flow and emotions. Further tests were devised and carried out in order to gain an even deeper understanding of these findings. An initial test aimed to provide more qualitative data, with a second test designed to provide quantitative data to add further validity to the results of the music and animation study.

#### **8.1 Qualitative test**

The aim of this test was to gain a deeper understanding of the participants' feelings during the test and the factors which caused them to experience these feelings. This was intended to obtain a more qualitative insight into the results, in turn enabling more informed conclusions to be drawn.

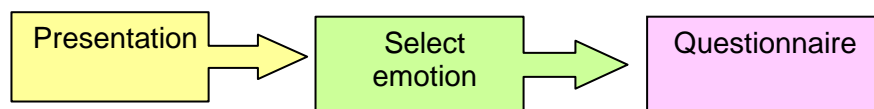
As the original test was anonymous, participants of the test could not be located for the purposes of eliciting further information about their feelings. Additionally, a large amount of time would have passed from when the participants took the test and it was likely that they would have forgotten how they felt and why they felt that way. This therefore led to a new test being designed and carried out.

## Qualitative test design

Several experimental designs were considered and the pros and cons of each are discussed. The experimental designs considered included those shown below.

### Qualitative test design 1

Have the participant watch a presentation and then indicate how they felt and complete a questionnaire that specifically asked why they felt a particular way during the presentation.

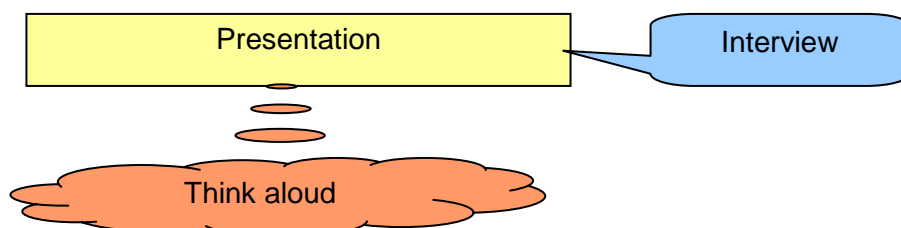


**Figure 8.1 Qualitative test design 1**

Other variations on this design would be to have an open-ended question area at the end of the presentation instead of using a structured questionnaire, or have an interview session at the end.

### Qualitative test design 2

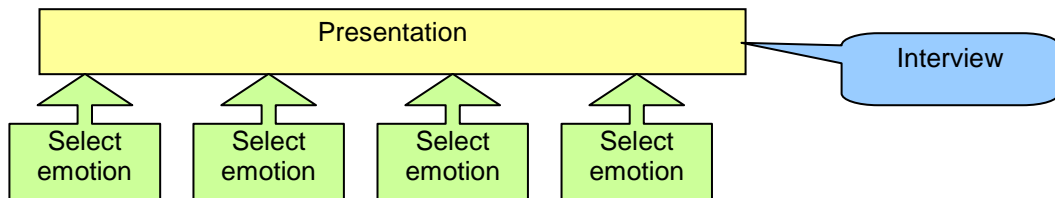
Have the participant watch the presentation and verbalise how they were feeling. At the end of the presentation, interview the participant in order to gain an understanding as to why they felt a particular way.



**Figure 8.2 Qualitative test design 2**

### Qualitative test design 3

This design involved the participant watching the presentation and indicating how they felt at various stages throughout it. At the end they would then be interviewed as to why they felt the way they did.



**Figure 8.3 Qualitative test design 3**

While each of the above designs has some merit, it was felt that having to watch the presentation and verbalise thoughts at the same time would be too much of a distraction for the participants. Thus design 2 was not used. Design 1 provided a sound experimental design, but it was felt that in order to gain the maximum insight into a participant's emotions and state of flow, having only one section at the end of the presentation to indicate emotions was not satisfactory. The idea of a closed questionnaire to elicit further information as to why a participant felt a particular way was also rejected as it would be too limiting and it would be unlikely to enable a deep understanding to be gained. Utilising an open-ended question format would have been preferable to the closed questionnaire format, but again it would only elicit information about the feelings that the participant was aware of at the time. An interview situation seemed the most desirable of the three options, as in an interview situation if the participant indicated a particular aspect this could be followed up by the interviewer and the reasons why could be probed further. Design 3 provided more key ways for the participant to indicate their feelings and had the advantage of having a interview to probe the reasons why the participant felt a particular way.

Several more issues were considered. It was decided that a sample of participants should be interviewed by a psychologist rather than the researcher. The interviewer would be someone not associated with the research prior to this interview so they would not show bias or unintentionally lead the interview in a particular direction because, unlike the researcher, they would not know the results from the music and animation study.

It was intended to keep this experiment as close as possible to the music and animation study experimental design to ensure that as few variables as possible would change. However, as this study had a slightly different focus and was collecting different data it would obviously differ from the music and animation study in some ways. Thus further development to the experimental design included deciding whether each participant should be presented with one of the four presentation situations, or presented with all four. Ideally each participant would have been presented with one presentation situation, but it had to be taken into account how resource heavy this would have been in order to gain any amount of meaningful data. The interviewer would only be able to elicit information about that one intervention situation from each participant. Hence it was decided that each participant would be presented with all four different situations, but that these would be incorporated within one presentation.

In order to ensure that the sequence of interventions would not have a biased effect, the participants would be allocated the interventions in a random order. It was felt that interviewing eight participants would provide enough data for analysis, thus a selection of four different combinations of situation order were to be used. Of course there were many more different permutations of these combinations, but it was judged that four would provide a fair degree of randomisation between the eight participants. Due to the

nature of the presentation architecture it was not possible to randomise the presentations in real time. Below are the four different combinations:

1. A, N, M, MA
2. M, N, MA, A
3. MA, M, N, A
4. A, MA, N, M

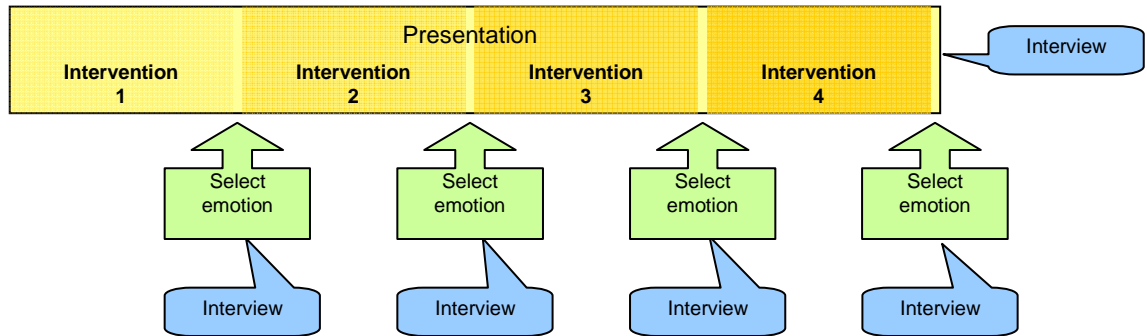
Each participant would view one of these, e.g. if they were watching presentation 3 they would see a group of slides containing the MA interventions, then the M interventions, followed by the group with no music or animations, and lastly the group of slides containing the A interventions.

The positioning of the intervention slides were kept the same as in the music and animation study, i.e., slides 2, 9, 13, 20, 22 and 25. This was done to maintain as much consistency across the two tests as possible.

As in design 3, after viewing each of the intervention groups a participant would be asked to select an emotion from a list that best described how they felt during the intervention slides. The emotions available to select were arousal, enjoyment, control, boredom, relaxation, apathy, worry and anxiety, being the same as the emotions in the Experience Sampling Method (ESM) questions from the music and animation study, again to maintain consistency.

At this point the test design was different to design 3 since having the interview at the end of the presentation might mean that the participant could forget why they felt a particular emotion during the first stage of the presentation. Hence a new design (design 4) was developed in which a mini-interview would be carried out after each selection of

emotions, thus four mini-interviews would be carried out as well as an interview at the very end (Figure 8.4).



**Figure 8.4 Qualitative test design 4**

The selection of a particular emotion would be the starting point for the interview, with the psychologist asking the participant why they selected a specific emotion. This test would be carried out in a lab situation so as to allow the interviewer to observe participant reactions and carry out interviews without external distractions and in the same environment.

### **Architecture**

This test used a Flash animation as used in the music and animation study, but this would run on a stand-alone machine.

### **Sample**

Eight students from the University of Dundee were invited to participate. This allowed each combination of presentations to be tested twice. An invitation to participate was sent to postgraduates and undergraduates from within the University of Dundee, with the first eight who responded being selected.

## Results

A mixture of participants took part in the test, three males and five females. Three were PhD students and the remaining five were undergraduates. Six of the participants were from the computing department and two were from the sports science department.

### The animation intervention

One problem highlighted was that participants seemed to be unsure when the animations were finished and this was causing feelings of anxiety and worry. The interviewer also observed a degree of uncertainty in the participants' actions near the end of the animations as they seemed unsure as to when to click the next button to progress to the next slide.

One person also commented that the animation interventions "made me smile, but took attention away from what I was trying to learn".

### The music intervention

Six of the eight said that they liked the music, although two of those six commented that they felt it was also distracting them from the content.

One participant commented that "alternative music may have been better".

### The music and animation intervention

Six of the eight participants said that they liked it. One participant indicated that it helped her focus on the content. Another commented that he felt the music and animation was "good for entertainment, but not for learning".



### The intervention with neither music nor animation

The comments for this intervention generally related to the content rather than the method of delivery. One participant expressed feeling anxious about the content, as they were concerned that they would not be able to remember all of the content that was presented on one of the slides.

Most of the participants felt less distracted, but more bored without the music or animations.

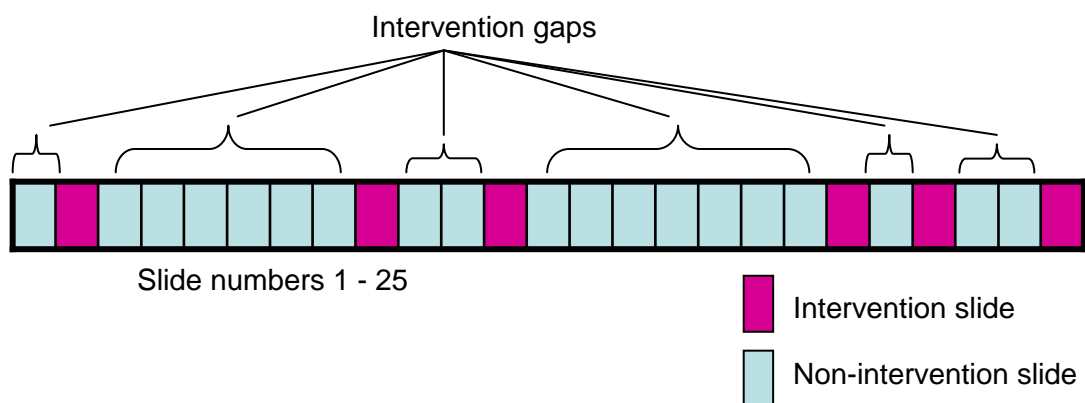
### Conclusions

This test provided a useful insight into why some of the emotions were selected. For example with the participant who felt anxious, it appeared their feelings did not relate to the interventions, but more to the content. It was also interesting to see that many of the participants liked the musical situations even though they felt that they may not be particularly conducive to learning, with some indicating that they may have preferred different music. While user selected music had been considered during the design of the main experiment it was not practical to have different styles of music as it would have meant the animations would have had to be choreographed to each particular piece of music. The clearest indicator from these results was that the animation interventions were causing participants problems as they were unsure when the animations on the slide had finished.

## 8.2 Validation test

One uncertainty about the results from the music and animation study which remains is that it was not clear if the participants were reporting the feelings experienced as a result of the interventions, or as a result of the gaps between the interventions (Figure 8.5).

Thus an experiment was devised to provide evidence to identify if the participants' feelings were being reported in relation to the intervention gaps or the actual interventions.



**Figure 8.5 The intervention gaps**

### Validation test design

As for the previous qualitative test, it was important to keep the presentation design as similar as possible to that used in the music and animation study to allow a sound validation process to take place.

This test would utilise the infrastructure already in place for the music and animation study, using the same technology and design format, i.e., an introduction including the informed consent and explanation about the test. However, this time the introduction would be followed immediately by the presentation, and there would be no learning

attainment tests or ESM questions after the presentation due to the focus of this test being very specific and these additional question sets being unnecessary.

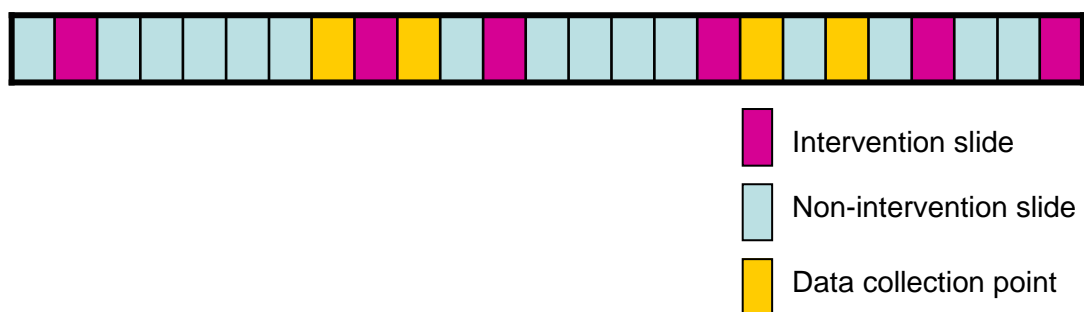
Several test designs were considered, all of which had the aim of identifying participant feelings after an intervention section and after a non-intervention section. The difference in these designs was not each type of intervention i.e., having the MA, M and A situations tested, but whether each participant should be presented with one or all of these situations. Lastly a decision was required as to how many times the participant would be asked to indicate how they were feeling. Obviously they would have to be asked at least twice, once after an intervention situation and once after a non-intervention situation. However, if they were to be presented with all the situations then they would have to be asked at least four times, once after the non-intervention situation and again after each of the other three interventions. Whilst it would be more thorough to use the latter design of presenting and recording data for each of the interventions, a further consideration for this test design would be that the order that the intervention situations were to be presented in would need to be randomised to negate possible effects of the intervention order.

On weighing up the various options for this test design it was decided that one intervention situation would be used. Since the aim of this experiment was simply to identify if participants were reporting their feelings in respect to the intervention gaps or the interventions, not all interventions needed to be investigated. Additionally if all interventions were investigated then a very large sample size would be required in order to fulfil the randomised ordering of interventions.

Having decided that only one of the intervention situations would be presented, the results from the music and animation study were reviewed to establish which to use. Since the MA situation showed the greatest variation with the N situation, with MA

producing a significantly lower score than N ( $p=.001$ ) for the ESM total, it was decided that this was the situation which would be used.

To ensure that the order in which feelings would be recorded after an intervention or non-intervention was not an influence, four sets of ESM recordings would be taken. Two recordings would be taken directly after music and animation intervention slides and two recordings directly after non-intervention slides. These recordings would be completed in two sets; the first set starting with a non-intervention slide followed by data collection and then the MA situation followed by data collection, and the second set starting with the MA situation followed by data collection and then the non-intervention slide followed by data collection (see Figure 8.6). It is worth noting that some of the slides from the music and animation study presentation were not included in this presentation, such as the slides where the participant was asked to indicate their learning styles. This was because it was not necessary to record this data and these were particularly interactive slides so it was felt their inclusion might have contributed to the participants' feelings, and with the aim of this test being very specific it was felt best to exclude these slides.



**Figure 8.6 The data collection points during the presentation**

### **ESM question design**

Asking participants to complete the full ESM four times during the presentation was thought to be far too disruptive, and so instead of using the full set of ESM questions a

shortened set was used. In order to select which question to use in this shortened set the results from the music and animation study were reviewed.

Since the results from the music and animation study revealed that the constructs of clear goals and feedback were emotionally the least significant of all the constructs (as will be discussed in chapter 9) it was decided that these constructs would not be included in the shortened ESM question set. Also the level of skill and challenge was omitted since this was recorded using a different methodology to the other flow constructs in the music and animation study. The remaining constructs of *loss of self-consciousness / telepresence, concentration, focus, control* and *transformation of time / time distortion* would be recorded. It was decided that in order to keep the cognitive load of the data collection to a minimum and cause as little disruption to the viewing of the presentation as possible, one ESM question would be asked for each construct. Table 8.1 shows three of the questions showing the most significance between the MA and N situations were selected: Concen1, Focus2 and Time2. Although the p value for Focus2 was not actually significant it was close to significant and the p value was higher than that for Focus1. Neither of the questions for the construct of loss of self-consciousness / telepresence (Tele1 and Tele2) showed any significant difference between MA and N, so the question with the highest p value was selected. The final construct of control provided one question, CTRL1, that showed a significant difference, while the other question CTRL2 showed no significant difference between the situations of MA and N. Thus it was decided to use CTRL2 as this would provide three questions that showed a significant difference and two questions that did not show any difference, allowing the results to be analysed for any expected similarities and differences.

**Table 8.1 Differences between the situations and the ESM questions**

Question code	Questions	Results of an ANOVA test for the difference between the intervention situations	p value for the difference between MA and N
Tele2	During the presentation, I forgot about my immediate surroundings	$F(3, 712) = 0.553, p = .647$	$p = 1$
Concen1	I was absorbed intensely in activity.	$F(3, 708) = 3.201, p = .023$	$p = .027$
Focus2	I thought about other things	$F(3, 711) = 2.986, p = .031$	$p = .056$
CTRL2	I always felt in control.	$F(3, 679) = 3.363, p = .018$	$p = 1$
Time2	Time went faster than I thought and I did not even sense it.	$F(3, 712) = 2.863, p = .036$	$p = .04$

### **Pilot**

Prior to the release of this test a pilot was run to ensure that it was clear to the participants how to complete the test. Fifteen participants completed the pilot and no problems were reported.

### **Sample**

First year students from universities and colleges throughout the UK were invited to take part in the test. This was done by emailing university and college staff and inviting them to view a sample of the test (where results were not recorded). They were then asked to pass the invitation on to their first year students if they wished. Only first year students were invited, as it was possible students beyond first year might have taken part in the music and animation study the previous year. It was not desirable for them to take this test since if they had seen it before this could affect their responses and their feelings towards the presentation.

## Results

A total of 85 participants completed the test.

Analysis of the results showed no significant differences between the first two data collection sets regarding the individual ESM questions. The same applied for the third and fourth data collection sets.

The individual ESM question results were combined for both of the non-intervention situations to produce a total for each of the ESM questions for the non-intervention situations, and the same was done for the ESM questions for the MA situations.

None of the ESM questions produced any significant difference between the non-intervention situations and the MA situations as shown in Table 8.2.

**Table 8.2 Differences between the situations when combined**

ESM question code	Expected result	Result between the combined non-intervention data collection points and the MA data collection points
Tele2	No difference	$t(84) = 1.303, p=.196$
Concen1	Difference	$t(84) = -1.240, p=.218$
Focus2	No difference	$t(84) = -.689, p=.492$
CTRL2	No difference	$t(84) = -1.725, p=.088$
Time2	Difference	$t(84) = -1.875, p=.064$

Lastly the ESM total was calculated for each situation and again no significant difference was seen between the non-intervention and the MA situations.

## Conclusions

Although not all of these findings were as expected based on the results from the music and animation study, these results did provide some supporting evidence for the results

of the music and animation study. There was no significant difference seen in the ESM questions Tele2, Focus2 or CTRL2 in either the music and animation study or this validation test, and so these results were as expected. However, in the music and animation study a significant difference was seen for ESM questions Concen1 and Time2, yet there was no significant difference seen in the validation test for these questions.

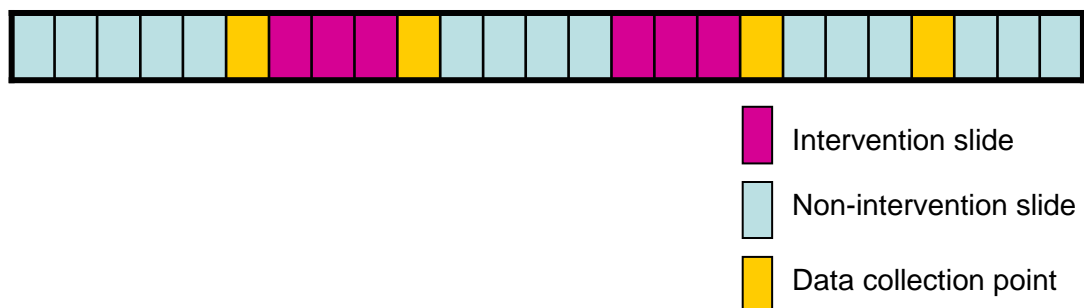
While this test did not provide conclusive evidence that participants were reporting their feelings about the interventions and not the intervention gaps, this might have been due to several factors. As each data collection set was separated by only one slide, perhaps the effects of flow were being carried over as there would have been little time between the first slide, the first data collection point and then the second slide and second data collection point of each set. Perhaps there was not enough time, change in the level of skill required or change in the challenge set for the effects of the slide type to have had an impact upon how the participant felt. Chen's (2006a) research indicated that during a web browsing task there was little change in the state of flow experienced, whereas Pearce et al. (2005) found that the level of flow fluctuated during different learning tasks. One may conclude from their findings that there needs to be a change in the level of challenge, and thus a change in the level of skill required to match the challenge, in order to cause a change in the state of flow.

Equally one could consider that this might also be due to the nature of the two constructs of concentration and transformation of time / time distortion and that there was not enough time for these constructs to have been affected by the different slide types. It may be that for time to be distorted there needs to be adequate time span set in the first place. One may consider how much a 30 second time period can be distorted,



whereas in the music and animation study the average amount of time taken to view the slides ranged from five and a half minutes to eight and a half minutes in the different situations. One may presume that a more apparent time distortion could occur over the longer period in the music and animation study than was seen in this test. The participants' levels of concentration may have been interrupted by the inclusion of the ESM questions whereas in the music and animation study the ESM questions were located at the very end of the presentation. It has been recognised that the use of the ESM during a task can have a detrimental effect upon the level of flow and it may have been due to the test design that the participants' levels of concentration were affected.

Other test designs were considered, for example Figure 8.7 shows a test design similar to the one used but there are a minimum of three intervention slides prior to each data collection point.



**Figure 8.7 An alternative test design**

This design would have allowed a longer time period between the data collection points for any effects of the interventions to alter the participant's state of flow, particularly as the participant would be exposed to a more intense period of the interventions. However, this test design would have required the slides to be re-ordered to allow the intervention slides to be run consecutively, or alternatively the slide order would have

remained the same and new animations could have been created on the appropriate slides. In either case this degree of change to the original test design meant that it could not have provided validation for the music and animation study as it would be too different from the design of this study, and so it was rejected.

## **CHAPTER 9**

### **DISCUSSION AND EVALUATION**

This chapter discusses the findings of this research. The evidence provided is examined in relation to the hypotheses proposed at the beginning of this study. Other findings within the results are also discussed.

#### **9.1 Factors influencing learning attainment**

Analysis of the learning attainment between the different situations (result A1) showed that hypothesis 1.1 “There will be a difference in the learning attainment within the four different learning situations” was not supported. There was no evidence of any difference in the learning attainment when animation and/or music were incorporated into the learning situation. This finding supports Larson’s (2009) findings where additional visual aids did not have any significant effects on the short-term recall of a presentation. However, the ESM total score varied significantly according to the presentation situation (result B2) and this provided clear supporting evidence for hypothesis 1.2 “There will be a difference in the learner’s ability to enter a state of flow between the four different learning situations”. It was surprising to find that the learning attainment was unaltered across the different learning situations when there was such a significant difference seen in the emotions of participants between situations. It was anticipated that emotions would have a greater impact upon learning attainment than it did, as evidence exists that supports the idea that a learner’s emotions have an impact upon their learning process (Ho & Kuo, 2009; Choi et al. 2007; O’Regan, 2003;

Sylwester, 1994). However, there were no significant findings to suggest that emotions had any influence upon a participant's learning attainment.

Perhaps one reason for these findings was the nature of the learning situation, being a relatively straightforward learning task using a PowerPoint style of presentation. Another reason may have been due to the design of the pre- and post-knowledge tests. Although there was no difference seen in learning attainment between the four situations overall, a clear difference was found between the learning attainment of undergraduate students and college students (result A2). The undergraduates' learning attainment was significantly higher than that of the college students. Since the students' year of study was not recorded, it could be assumed that some of the undergraduate students were in the more advanced years of their study, and hence may have been more attuned to learning than some of the college students. Alternatively, perhaps the differences in these results were due to the manner of study that undergraduates and college students are accustomed to. One may also consider that college students are generally more used to a classroom setting and being guided by the lecturer through the learning process, whereas undergraduates, whilst having lecture sessions, experience a more self-directed learning experience at university. Perhaps these differences in learning structure and learning environment meant that the undergraduate group were better prepared than the college group to learn from this style of educational delivery. Of course a PowerPoint-style presentation is just one method of delivering e-learning; many other delivery methods exist and without further research it is unclear if these results can be generalised to other methods of delivery or not.

There may also be a link between the student's perception of their learning styles and their ability to learn from such presentations, since significant differences between the

student groups and their perceived learning styles were found in results G2, G3 and G4. It was proposed in hypothesis 3.1 that “The learners’ perception of their learning styles would have no effect upon the learning attainment” since it is a popular belief that learning styles are not linked to learning attainment. The results from this study demonstrated a clear link between the perceived learning styles and the learning attainment, showing hypothesis 3.1 to be false. Those who considered themselves to be intrapersonal according to the Gardner’s Multiple Intelligences (GMI) (result H1) scored higher in the value score than those who did not consider themselves to be intrapersonal. The value score was also significantly higher for those who selected the GMI category of logical/mathematical. A similar result was found for those who selected Myer-Briggs Type Indicator (MBTI) sensing rather than intuitive. While this research did not collect data about participants’ actual learning styles it does show that there may be value in collecting data about people’s perceptions of their learning styles as this apparently does have an impact upon their learning attainment. Of course it may not always be possible to collect such data since the person would have to be well informed about learning styles in order to self-report their perceptions of their learning styles accurately. It should also be considered that the results from this study only indicate that the learning attainment is affected by the perceived learning style when presented with this type of learning situation, and a different learning situation may produce different results.

The total time participants spent viewing the presentation had an effect upon learning attainment. Result A3 showed a positive correlation between the time taken to view the presentation and the value score. The reason for this is likely to be that participants who took longer to view the presentation were taking more of an interest in the content and

perhaps spending more time reflecting upon it, and hence their learning process was deeper than those who took less time.

A correlation was also found between the total number of revisits to previous slides in the presentation and the learning attainment (result A4). However, when each of the situations were analysed separately only the situation without music or animation (N) and the music and animation (MA) situation showed any significance. It is difficult for one to attribute any meaning to these findings, despite their apparent significance, other than to assume that the higher the number of revisits to previous slides, the more the participant was reflecting during the learning process and felt the need to return to a previous slide to consolidate a particular aspect. Of course one might also expect that the greater the number of revisits to previous slides, the longer the overall viewing time of the presentation. If this expectation was indeed the case, it would be difficult to determine if it was the total time spent viewing the presentation that was the direct cause of the increase in the learning attainment, or the effect of revisiting previous slides.

The perceived level of challenge and skill of the participants correlated to the learning attainment (result A5). Where the level of challenge was considered to be higher, learning attainment was lower, and this supports the findings of others. For example, Finneran and Zhang's (2002) review of flow studies explored the effects of skill and challenge upon learning, while Pace (2004) found that learning was affected by the level of challenge presented in the learning task. Conversely, where participants' perceived level of skill was reported to be high, their learning attainment was also higher, and again these findings support other research in this area.

This method of self-reporting perceived challenge and skill may be a very useful indicator as to the demands that are being placed upon the learner. Even in this fairly unchallenging presentation-style learning situation it was clear that the perceived challenges set and the perceived skill levels of participants had an impact upon learning attainment. Thus the potential usefulness of recording such data should not be underestimated by educational designers.

## **9.2 Users' flow experiences**

The results clearly supported hypothesis 1.2 “There will be a difference in the learner’s ability to enter a state of flow between the four different learning situations” (result B1). It was anticipated that a participant’s ability to enter a state of flow while watching the presentation would be greatest with the addition of the music and animation (MA situation). This was expected to be because of the environment being more immersive and thus it was expected to capture the attention of participants more than other situations. However, the opposite was found to be true, with participants demonstrating more potential to enter a state of flow when there was neither music nor animation present (N situation). Results from qualitative tests, as described in chapter 8, provided an insight into the reasons for this, with one of the main reasons appearing to be due to the type of music used.

Although the music was selected because of its arousing and positive attributes (as described in chapter 4), it may not have been the most suitable style of music for this particular learning situation. The notion that the audience, or in this case the students, might not be the best people to select the music was discussed in section 5.9. Indeed, it was suggested that a potential film audience might not be the most suitable people to select music that would evoke particular feelings in a film. Even if asked to select

arousing or sad music, their specific selection might not create the desired effect when embedded into the film. In the same manner, within this study it was interesting to see that the inclusion of music and animation had the desired effect in the initial pilot study, described in chapter 3, but of course with such small numbers there was always a risk of the Hawthorne effect (Clark, 1999). However, music was selected by the researcher and seemed to create a positive and pleasing effect amongst participants. Yet when the music was selected by students and then embedded along with the animations into the presentation used in the music and animation study it was obviously not as well-received as it was for the pilot study. Of course there were differences between the initial pilot study and the music and animation study which could account for the difference in the participants' appreciation of the embedded music and animation. Not only was different music used, but as the presentation content was different this meant that the animations were different and these could also have been contributing factors to the difference in the results. Although several different experimental designs were considered at the outset with regards to the style of music and animation, such as allowing the participant to select their own music preferences, it was not considered feasible to manipulate the animation timings to fit with self-selected music in real time. It would also have been difficult to draw any sort of comparisons between a music intervention and the other interventions, as there would be such a wide variety of music interventions possible.

As expected the animation only (A) situation reduced a participant's ability to enter a state of flow when compared to the N situation (result B1). The A situation was expected to be the least conducive of the four situations in evoking a state of flow, with previous research, such as that carried out by Cairncross and Mannion (2001) and Stanton, Porter and Stroud (2001), indicating that the learner having control over the



pace of learning was an important factor. Although much of this research focused on the effects of learner control on the learning process rather than examining the link between the learner control and their emotions, it was anticipated that participants in the A situations would experience a sense of lack of control over their learning pace since they would be inclined to wait until the animation sequence had completed rather than proceed at their own reading pace, and this would adversely affect their state of flow.

The MA and A situations were both significantly less conducive than the N situation to the participants entering a state of flow, whereas the music only (M) situation was not, and it seems that it was the inclusion of the animation that reduced the potential state of flow rather than the inclusion of the music. One may conclude that the impact of embedding music in an e-learning environment had less impact upon the learner than the inclusion of animation in the environment. Thus educational designers should be careful when considering which music to include, and take greater care when considering which animations to include, if they are necessary at all.

The presentation did not have music and animations all the way through, interventions only happening at six intervals throughout the presentation. There were several sections where the slides had no music and/or animations – the ‘intervention gaps’. This led to a concern that participants might have been reporting feelings based upon intervention gaps rather than the interventions themselves. A further test was carried out to establish if the findings were related to the intervention gaps or to the interventions, as reported in chapter 8. The findings from this did not provide conclusive evidence that the music and animation study results related directly to the interventions and this result may have been due to the nature of flow experiences. Since previous research by Chen (2006a) and Pearce et al. (2005) indicated that flow experiences appeared to change in

accordance with changes in the level of challenge posed by the task and the skills required to complete the task, one could assume that the inclusion or exclusion of music and animation would have little short-term impact upon the level of flow as seen in the final test. In the music and animation study a difference in the flow experiences was seen between the situations, and perhaps this was as a result of the longer-term impact of the inclusions of music and animations. Also the level of skill and challenge was unchanged other than an additional level of skill or challenge that may have been required to listen to the music and watch the animations. However, one could presume this to be minimal as there were no significant differences seen in the results for the level of skill and challenge between the four different situations.

Perceived learning styles also impacted upon a participant's potential to enter a state of flow, which was contrary to hypothesis 3.2 "The perceived learning style will have no effect upon the learner's ability to enter a state of flow". Those selecting GMI body/motion had a higher potential to enter a flow state than those who did not select this category (result H2). This may lead one to speculate whether people with a perceived preference for this learning style generally find it easier to enter a state of flow than those who do not have this perceived preference, or if it is only within this type of learning environment that this perceived learning style lends itself to a flow experience.

The Experience Sampling Method (ESM) total (i.e., the participant's potential to enter a state of flow) was closely linked with the emotions the participants indicated they felt during the presentation (result B2). This provides good evidence that the ESM total is a good indicator for a participant's perceived emotional state. The ESM total was significantly higher for the positive emotions of arousal, enjoyment and control than the

more negative emotions of apathy, boredom and anxiety. Relaxation also produced a higher ESM total than boredom and apathy, although relaxation may not be considered to be the most ideal emotion for learning, but it could be presumed to be a more preferable emotion than boredom or apathy.

### **9.3 Factors affecting flow**

It was hypothesised that the different flow constructs would be affected in different ways with the inclusion of music and animation. While some of sub-hypotheses 2 were shown to be true others were not. This section details these and also discusses various factors that may have influenced these flow constructs.

#### **Effects of music and animation upon the flow constructs**

As expected the inclusion of music and/or animation did not have an effect on the flow constructs of clear goals, feedback or skill and challenge. These constructs were considered to be more related to the content rather than the method of delivery, and actual content remained unchanged between the four situations.

The hypothesis for the level of control being negatively affected by the inclusion of music and/or animation was also supported. Within each of the intervention situations, the perceived level of control was significantly lower than for the N situation (results B4 and B5). As discussed in chapter 6 this was likely to be due to participants feeling that they should wait until the animations had completed before moving on to the next slide, particularly as there was no provision for participants to control animation speed other than to click the 'next' button to reveal the completed animation sequence.

Interestingly, although the M situation produced a more negative level of control than the N situation it was significantly more positive than the MA and A situations. Thus one could assume that participants felt more able to move to the next slide before the music had finished, unlike animations where they felt more obliged to wait. With no music or animation participants felt completely in control of when to move on. It is worth considering whether the reason for these findings may be due to familiarisation. Most people are used to presentations without music or animation, as well as the navigation procedure, and hence may feel more in control. Perhaps the inclusion of the music and/or animation was a relatively unfamiliar method of delivery for participants and they did not know how best to deal with the situation. However, if this was a significant issue for people then one would have expected the level of challenge or the level of skill required to have been more affected than it was.

For the ESM question “I felt frustrated” which related to the control construct, results showed that the animation situation was the most frustrating of the four situations (result B4). Research by Scheirer et al. (2002) showed that participant frustration could be induced by deliberately creating a slow computer game interface, and in a similar manner it is feasible that the time delay in the A intervention slides caused a feeling of frustration as found in Scheirer et al.’s research. The average time participants spent viewing the A intervention slides was 202 seconds, whereas the average time spent viewing the same N situation slides was 55 seconds. This shows the A intervention slides took nearly four times as long as the corresponding N situation slides.

The MA situation also negatively affected participants’ feelings of concentration and transformation of time (result B6). It was hypothesised that the inclusion of music and animation would have a positive effect upon these components of flow. One could postulate that it was the lack of concentration which led to the negative results for the

transformation of time. If a participant was not fully absorbed in the task at hand, it is unlikely that time would appear to pass quickly. It seemed that the combination of music and animation affected the participants' concentration levels more than the inclusion of only the animation or the music. This was perhaps due to participants having to deal with more subconscious input from different channels during the MA situation as there was audio input as well as visual input being subconsciously processed on top of the content that must also be processed. With the M and A situations there was less information requiring processing.

It was noted in chapter 4 that many people listen to music while working online in order to help them concentrate. However, in this test the inclusion of music alone did not enhance participants' levels of concentration, and there could be several reasons for this. Firstly, it would have to be ascertained whether people actually concentrate more when they are listening to music while working. Secondly, concentration levels could be affected by the particular piece or style of music being listened to while working. The results in chapter 4 found that classical and rock were the most popular styles of music to listen to while working. Jazz was not popular to listen to while working, but was a popular style of music to listen to for pleasure. Perhaps the style of music used in this research was not as conducive to concentration as classical or rock music may have been. There is also the question of familiarity with a piece of music. Listening to a piece of music for the first time may require more concentration and cognitive processing than listening to a piece with which one is familiar. The music used in this research was specifically selected to be unfamiliar to participants, and this may have taken more concentration and cognitive processing by participants when listening to the music and watching the animations.

Given that the MA situation had a detrimental effect upon levels of concentration, it could be logical to suggest the MA would have a similar negative effect upon level of focus. However, this was found to be unchanged thus indicating that the inclusion of the music and animation, either individually or combined, did not have any significant effect upon participants' levels of focus. It was hypothesised that the inclusion of music and animation would increase participants' focus since it was expected that they would become more immersed in the e-learning environment, which would in turn cause them to experience a feeling of loss of self-consciousness. However, the participants' level of self-consciousness also remained unchanged across all of the situations. This may be because music and animation has no effect upon these flow constructs or, perhaps as a consequence of the test design, the amount of music and animation incorporated into the presentation was not enough to affect these constructs, having only six 30 to 40 second intervals of the interventions. If the music had been played throughout the entire presentation this might have produced different results.

Table 9.1 gives a summary of the effects of music and animation upon the flow constructs. It shows that the construct of control was the only construct to be affected by all of the intervention situations. This suggests the construct of control is the most susceptible to the influences of additional presentation attributes such as music and animation. The constructs of focus and loss of self-consciousness were less vulnerable to additional presentation attributes. It could be concluded that the more additional presentation attributes included, the more of an effect they have upon the flow constructs. Table 9.1 clearly shows that while the inclusion of only animation or only music affected only one construct, the inclusion of both music and animation affected three of the attributes.

**Table 9.1 Summary of the effects of music and/or animation**

<b>Hypothesis</b>	<b>Construct (as described by Csikszentmihalyi)</b>	<b>Hypothesised effects of music and/or animation</b>	<b>Actual effects of music</b>	<b>Actual effects of animation</b>	<b>Actual effects of music and animation</b>
2.1	A clear goal	None	None	None	None
2.2	Feedback	None	None	None	None
2.3	Challenges match skills	None	None	None	None
2.4	Concentration	Positive	None	None	<b>Negative</b>
2.5	Focus	Positive	None	None	None
2.6	Control	Negative	<b>Varied*</b>	<b>Negative</b>	<b>Negative</b>
2.7	Loss of self-consciousness	Positive	None	None	None
2.8	Transformation of time	Positive	None	None	<b>Negative</b>

\* Note that for control M was more positive than MA and A, but was negative compared to N

### **Flow constructs and the emotions**

A clear match was seen between the emotions selected by the participants to describe how they felt during the presentation, and the scores for the individual flow constructs (result B3). These results showed that the more the participant was experiencing a construct, for example a transformation of time, the more positive emotion selected, such as arousal or enjoyment. These results fit very well with Csikszentmihalyi's theories of flow indicating that positive flow experiences are closely linked with positive emotional experiences. The only ESM question that did not produce any significant differences was for the construct of feedback, this was FDBK2 "I knew how well I was proceeding". The other ESM question for feedback only indicated one significant difference between the emotions. One reason for this might be due to the test design, as there was not a strong need to provide feedback to participants. The only feedback provided was the slide number, how many slides there were in total, and a

small message providing further information about a particular MBTI selected (happening at one point during the presentation where participants indicated which MBTI learning style they felt they fitted best with and made a selection from four choices). Thus, it was not unexpected that this construct produced the least number of differences in the emotional selection. Table 9.2 gives the total number of significant differences between emotions for the flow constructs. It shows that the construct of transformation of time/ time distortion produced the most number of differences. These results suggest that the constructs of transformation of time, control and concentration are most strongly linked with the emotions.

**Table 9.2 Summary of the flow constructs and emotions**

<b>Flow construct</b>	<b>Total number of significant differences between emotions</b>
Transformation of time/ time distortion	19
Control	18
Concentration	18
Focus	10
Loss of self-consciousness	10
Clear goals	4
Feedback	1

#### **9.4 Skill, challenge and the eight-channel model of flow**

The flow constructs of skill and challenge are often considered to be the most important indicators of flow experience and so are discussed in greater detail below. The levels of skill and challenge were also analysed in conjunction with the selected emotions in order to provide validation for the eight-channel model of flow.



### **The effects of skill and challenge**

A correlation between the ESM total and the level of perceived challenge was evident (result D1), which meant that the higher the perceived challenge the greater the ESM total and so the more likely the participant would be to enter a state of flow. This supports the findings of others such as Ho and Kuo (2009), Choi et al. (2007) and Shin (2006) who discussed the importance of the skill and challenge constructs of flow. Further detailed analysis showed that in particular the constructs of concentration, loss of self-consciousness/telepresence and transformation of time/time distortion were strongly correlated to the perceived level of challenge (result D3). However, the constructs of clear goals, focus, control and feedback were less affected by the perceived level of challenge. It is interesting to note that Chen (2000 cited in Finneran & Zhang, 2003) identified 3 distinct stages of flow: antecedents of flow, flow experience, and consequences of flow. The constructs of concentration, loss of self-consciousness, time distortion and telepresence all come under the category of flow experiences, while the constructs of clear goals, immediate feedback and potential control are classed as antecedents of flow. Hence one could conclude that if using Chen's model, the antecedents of flow are less affected by the level of challenge while the consequences of flow are strongly affected by the level of challenge.

There was no significant correlation between the level of perceived skill and the ESM total (result D2), but there were significant correlations between the individual flow constructs and the level of perceived skill (result D4). While the challenge construct had a clear correlation with the flow constructs, the skill construct had a varied effect upon the flow components. The greater the level of perceived skill, the greater the feeling of control and the clearer the goals, although the less concentration the participant felt, the

less feedback they felt they had. They also experienced a diminished sense of time distortion the greater the level of skill.

Overall these findings imply that the greater the perceived level of challenge a task presents the more conducive this is to a person's experience of flow, and the higher the perceived level of skill the greater the level of control and direction (clear goals) the person will have, although their feelings of concentration and involvement in the task (time distortion, feedback) will be reduced. Result D5 showed that within each of the different intervention situations, the effects of the perceived level of challenge remained unchanged by the inclusion of the music and/or the animation. Thus one could conclude that the inclusion of music and animation would not have any influence upon the usefulness of the challenge and skill constructs as indicators of other constructs or as an indicator of flow. Additionally one may also conclude that the constructs of challenge and skill are more dependent upon the content of a learning situation than the method of delivery.

The reported learning styles showed a correlation with the level of perceived skill and challenge (result D7). In particular, the styles of GMI intrapersonal and logical/mathematical produced a significant correlation with the levels of skill and challenge. The level of skill was increased where participants indicated themselves to be intrapersonal and the same was true for those who selected logical/mathematical. Conversely where these learning styles were selected the level of challenge was seen to decrease. One could deduce from these findings that people with these learning-style preferences feel more skilled, and hence were less challenged by the type of learning task used in this research. It is also interesting to note that these two styles had an effect upon the learning attainment, as discussed in section 9.1. Likewise with the MBTI, those who selected Introversion, Sensing, Thinking and Perceiving (ISTP) also

considered themselves to be more skilled than those who selected Extroversion, Intuitive, Feeling and Judging (ENFJ) (result D6). Although there was no significant difference seen in the level of challenge felt. Again there is a similar link with the learning attainment results, with those who selected sensing as opposed to intuition scoring higher in the results for learning attainment. Interestingly the undergraduate student group selected these learning styles more often than the college student group, and learning attainment was also higher for the undergraduate group (discussed in section 9.5).

These results show that the flow constructs of skill and challenge are clearly important constructs and not only provide an indication of flow potential, but also have a relationship with other elements, such as learning style.

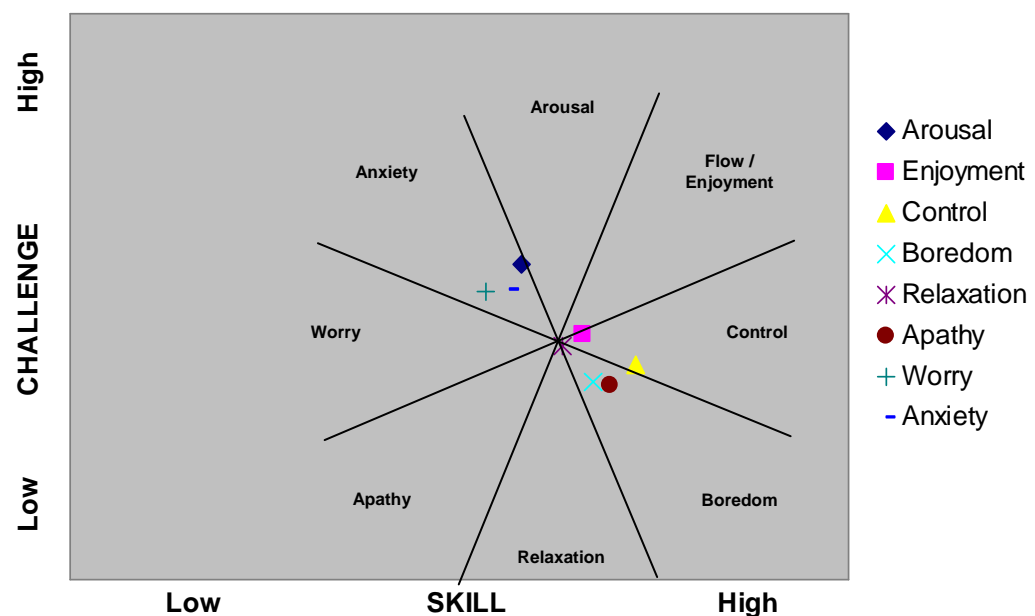
### **The eight-channel model of flow validation**

The test was designed to collect data in such a way that a comparison could be made between the level of skill and challenge perceived by the participant and the emotions they felt during the task. This allowed for direct mapping of the selected emotions onto the skill/challenge graph and thus for a comparison to be made. The aim was to see how well-matched the selected emotions would be with those of the eight-channel model of flow.

Whilst no direct correlation was identified between the emotions selected and the position on the skill/challenge graph representing the eight-channel model of flow (result C1), the results did provide some supporting evidence for the eight-channel model of flow. Significant differences were found in the positions of some of the emotions along the skill and challenge axis (results C2 and C3). There was a wider

spread and more significant differences along the challenge axis than along the skill axis, and all the emotions were still somewhat clustered within the mid-to-low challenge and mid-to-high skill area of the graph. This is believed to be a side-effect of the test design as the challenge that can be set in a presentation of this style is limited, as is the level of skill required to click through such a presentation. One could presume that these differences would become more apparent if using a more challenging task that required a greater skill level.

Figure 9.1 shows that if an allowance is made for the level of challenge posed by the task and the level of skills required, the positioning of the eight channels could be adjusted to find the best fit. One might then see that the emotions of control, boredom, and anxiety fit well, while the emotions arousal, enjoyment and relaxation are a close if less perfect fit. However, the emotions of worry and in particular apathy are not a good fit. Of course only some of the emotions showed significance in their positions relative to other emotions, and thus Figure 9.1 is demonstrating how the eight-channel model could be repositioned to suit the skill and challenge levels posed by a particular task.



**Figure 9.1** The eight-channel model of flow mapped to the emotions

## 9.5 Other findings

In this section further findings that are of interest, but were not directly related to any of the hypotheses, are discussed.

### Viewing times

Firstly it was an interesting finding that although the participants took significantly longer to view the MA and the A situations than the M and N situations (result E2), as was also the case when just the intervention slides were analysed (result E3), the ‘natural’ timing (i.e., the amount of time the slides would run from start to finish of the music and/or animation) of MA and M were actually the same and A is shorter (see Table 9.3).

**Table 9.3 Results from each of the presentations (n=722)**

Presentation type	‘Natural’ total time of the 6 slides with interventions	Mean time taken by participants to view the 6 intervention slides
MA	235 seconds	210 seconds**
M	235 seconds	67 seconds**
A	205 seconds	202 seconds**
N	n/a	55 seconds**

\*\* = significant at  $p < 0.001$

It would seem that it was not the music playing, but rather the animations that encouraged participants to view the screen for longer, despite the provision of a ‘next’ button that could be clicked at any time to reveal the final state of the slide.

Animation speed was increased for the A situation since during the design stage of the test, participants considered them to be too slow when not accompanied by the music (described in section 6.8). This raises an interesting point as to why the animations were considered to be of an acceptable speed when accompanied by the music, but not when viewed without the music, particularly since during the music interventions the participants moved to the next slide well before the music had finished. Perhaps it was because the participants had more information to process when viewing the MA situation with both the audio and visual channels being stimulated. Alternatively it might be, as one participant described in the qualitative tests (see chapter 8), that they found the music and animation situation to be good for entertainment and so the participant waited and viewed the slides for longer. However, since the animation alone was still viewed for considerably longer than the M or N situations, one is drawn to the conclusion that the reason for this longer viewing is more associated with the incorporation of animation than music.

The total time that participants spent viewing the presentation had an impact upon their learning attainment. The longer the presentation was viewed for, the higher the learning attainment (result A3). A relationship was also seen between the emotions the participants selected and the amount of time for which they viewed the presentation, with those who felt aroused spending much longer watching the presentation than those who were bored or those who reported feelings of apathy. One may assume that those who were experiencing feelings of boredom or apathy would click onto the next slide more quickly, perhaps not taking the time to reflect upon what they had just read, and hence resulting in a lower learning attainment. This is also supported by result A4 which details how the total number of revisits to a previous slide is positively correlated with the value score for learning attainment. Again it would appear that those who were

taking time to consolidate and reflect upon their learning by returning to previous slides were also learning more.

The age of the participants had an effect upon the amount of time they spent viewing the presentation, as shown by result F1, with the younger group of 16-20 year olds taking less time to view than the older group of 21-30 year olds. There was no clear reason for this difference in viewing time and there was no significant difference seen in learning attainment between these groups.

### **Differences between college and undergraduate student groups.**

As discussed in section 9.1, there were differences between the undergraduate and college students and their learning attainment. However, further differences were also revealed, such as the time of day students took the test, which varied significantly. For the undergraduate group, time of day was spread fairly evenly throughout the day, whereas for the college group there were significantly more college students taking the test at 11am and 2pm. Perhaps this is due to the different structures of timetables between these groups, or alternatively the accessibility of computers for students. Undergraduates might be more likely to spread their work throughout the day than college students. There may also be a link with this and the participants' learning style preferences, as identified by Dunn, Beaudry and Klavas (1989) in their survey of learning styles, where chronobiology, the preference for learning at a particular time of day, can have an impact upon student learning. The actual reasons for these differences between the groups might be varied, but nonetheless it was a significant and interesting finding. This is particularly the case given that these results did not relate to just one or two colleges and universities where differences could have been attributed to individual

institutional timetables and structures, but rather the data was gathered from many universities and colleges throughout the UK. It appears to be a much more generalised difference between university and college students.

One of the most surprising findings was a significant difference in the self-reported perceptions of the learning styles between these two groups. Significantly more college students than undergraduates selected the group of Extroversion, Intuitive, Feeling, Perceiving in the MBTI scale, while more undergraduates selected the group of Introversion, Sensing, Thinking, Judging than college students. The interesting thing to note is that these two scales are the exact opposite of each other. These results were also supported by the results for the perceived GMI preferences that showed a higher number of undergraduates selected Intrapersonal than college students. Intrapersonal was used to describe people who prefer individual activities, finding it easier to think and concentrate when working alone, while in the MBTI an Introvert was described as a person who prefers ideas rather than actions, preferring to think about things alone rather than interact with others. Thus these two terms are essentially describing one and the same thing. The results also showed that there were more undergraduates who selected Gardner's Logical/Mathematical Intelligence. This also has a link to the MBTI of Thinking, as the MBTI Thinking axis was used to describe a person who is very logical and likes clear goals and objectives.

Although the results from these learning styles were self-reported, there appears to be strong evidence of differences occurring in the perceptions of learning styles between these two groups of students. This could be due to the differences in the structure of teaching between universities and colleges, or perhaps it is not a difference that is driven by the teaching, but more by the student populace. If, as has been suggested by researchers such as Pithers (2002), Robotham (1999) and Messick (1984), a person's



learning style is relatively stable over time, it would seem logical to assume that these differences are student-driven. This may lead one to consider if a person's perceived learning style preferences have an effect upon their choice of studying at university or college, or if their perceptions of their learning style preferences may impact upon a student's ability to flourish in a particular academic environment.

## **9.6 Evaluation and limitations of the design**

The tests used in this research were designed as robustly as possible. However, this study dealt with some variables that could be considered very difficult to quantify, such as emotions, music and animation. Music can be extremely variable, for example in its style, tempo, volume and quality, and animation too can be varied in the colours used, the size, and the speed of the animations. Every attempt was made to minimise these variations, for example by validating the list of emotions against two models and creating a separate test to select the music. However, due to the nature of these variables it must be assumed that the results may to some degree have been influenced by the variability. These limitations mean that although the results show that the music and animation presentation was less conducive to a flow experience than the presentation with neither music nor animation, this might have been due to the type of music being played and animation sequence used. A state of flow may be more readily induced with a different style of music or animation sequence. Similarly while the learning attainment was unaffected by the inclusion of the music and/or animation in this study, the inclusion of a different style of music and/or animation could have an effect upon learning attainment.

The method of music selection, whilst being scientific in its methodology, may not have been appropriate in this situation. For example, a film score may or may not have the desired effect upon the audience if the music was chosen by people in ignorance of the context it was to be used in, as opposed to the director selecting music according to what was deemed most appropriate to the situation within the film. This is really a question of music selection by scientific process versus artistic impression. Given the artistic nature of music, one may wonder if the scientific approach is the most suitable.

### **Online experimental design**

In chapter 3 the issues of online testing were discussed. Where possible the strategies suggested to deal with these issues were implemented during the design phase of the tests used in this research. These included:

#### **Question design:**

When wording the questions for the pre- and post-tests, an opt-out option was supplied.

The ESM questions presented a neutral option, meaning participants were not forced into selecting a positive or negative answer to the questions.

The design of the interface was kept consistent across the four different test situations except for the inclusion of music and animation.

#### **Experimental protocol:**

The music and animation study was designed so that participants were able to return to a previous slide within the presentation section of the test. They could return to previous sections of the test by using the browser ‘back’ button, but

this would cause data from previous sections to be recorded again. This ensured that the data collected was always stored within one record. Thus any records with incomplete sections were discarded during the analysis.

Participant honesty was not directly tested, although for the flow constructs two differently worded ESM questions were used for each construct in order to corroborate the findings.

During the music and animation study the IP address was recorded. Although the recording of the IP address can provide a degree of confidence that each participant is unique, data collected showed duplicate IP addresses. This was anticipated once it was clear that the participants would be mainly college and university students given that many of the participants could be taking the test in the same IT suite and thus, in some cases, might be using the same machine. For this reason the data from the duplicate IP addresses were retained during the analysis.

**Technical issues:**

A pilot study was carried out to identify any inherent problems with the test design.

Information about participants' computer skills was not elicited, but upon reflection perhaps should have been, as their level of skill might have influenced their reporting of their level of skill when viewing the presentation. However, as the majority of participants reported a medium-to high-skill level one could assume that they were competent enough in using a computer and that this did not have a large impact upon the results.

**Participant's environment:**

The environment in which participants were located when they participated in the music and animation study was unknown, but it was assumed to be their 'natural' environment for completing online tasks.

As the test data was to be recorded anonymously, recording participant behaviour via a webcam was not feasible.

**Self-reported learning styles**

The learning styles data collected in this research was all self-reported by the participants. Since the subject of the presentation was about learning styles and study methods the participants had been well informed about learning styles before they were asked to report their perceived learning styles.

However, it is unknown if the participants' actual learning styles would have matched their self-reported learning styles. As the focus and design of the test was centred on learning attainment and flow, it was not feasible to carry out further testing into learning styles. However, it was clear from the findings that participants' perceived learning styles contribute significantly to various aspects of the learning process both academically (i.e., the learning attainment) and emotionally. Even if the self-reported learning styles were not the participant's actual preferred learning styles (as may have been ascertained using a full test), it could be argued that this study has shown there is value in using self-reported learning style perceptions. Of course it should be remembered that due to the subject of this learning situation, participants were well-informed about learning styles prior to selection. With less well-informed participants,

self-reported learning style perceptions might not have been of as much value as they were in this study.

### **Learning attainment measurement methodology**

The number of questions posed to the participants was kept to a minimum in order to minimise the cognitive load since there would be three main sets of questions as well as two more questions within the presentation itself. However, it was described in section 9.1 how the learning attainment in this study was unaffected by the emotions of the participants and how this result was not supported by the findings of other researchers. This can only lead to two conclusions: firstly, the findings in this study were correct and given this particular learning situation there was indeed no impact upon the learning attainment by the participant's emotions, or secondly the measurements for the learning attainment were inaccurate. Whilst the questions asked were examined by a psychologist to ensure that their wording was appropriate and not leading in any way, there were a limited number of questions asked. Where it was appropriate, the questions related to the content on the intervention slides, and thus a total of just six questions were asked. One should consider the possibility that with this number of questions the data collected did not provide a true reflection of the participants' learning attainment. Nonetheless, the results for the learning attainment did show several significant correlations and differences, such as that found between the college and undergraduate student groups. It could be argued that the data collection methodology for the learning attainment was not so weak that it was unable to show any significance. The only way to provide a higher degree of confidence to ensure the findings in this study were correct would be to carry out further validation tests on the measurement methodology for the learning attainment.

## **CHAPTER 10**

### **CONCLUSIONS AND FUTURE WORK**

In this chapter the contributions to knowledge arising from this research are described and conclusions about the main hypotheses of this research are drawn. Conclusions about the additional findings are also described. Whilst the findings from this study have answered the research questions posed earlier, some of the findings have raised many more questions. This chapter provides suggestions for future research. Some of the suggested areas of research aim to build upon the research carried out in this study while others point to new fields of study.

#### **10.1 Conclusions**

The findings from this research have added to the body of knowledge and in some instances generated new research questions. New methodologies were created which can be utilised in future research. In this section the specific contributions to knowledge are described and the conclusions about the research questions are then discussed. This is followed by conclusions about the additional findings from the research.

##### **Contributions to knowledge**

This research has provided several contributions to knowledge. These contributions arise from three main areas of the research, firstly from the literature review, secondly from the methodologies developed in order to carry out the research and lastly from the results. The specific contributions to knowledge are listed below.

## **Literature review**

The literature review of publications which investigated flow in online environments identified:

- (i) The most frequently cited constructs of flow.
- (ii) The most common methods of measuring flow.
- (iii) The most commonly used questions within an ESM.

## **Methodologies**

During the development of the experiments for this research new methodologies were created. These included methodologies for:

- (iv) Measuring a listener's emotional variation over time.
- (v) Validating the eight-channel model of flow by measuring the perceived skill and challenge level and the perceived emotions.

## **Results**

The results from the experiments carried out in this research provided the following contributions:

- (vi) The inclusion of music and animation in an e-learning situation had no significant effect upon the learning attainment.

- (vii) The inclusion of music and animation in an e-learning situation had a significant effect upon the learner's ability to enter a state of flow.
- (viii) The effects of music and animation upon the individual constructs of flow were identified.
- (ix) A significant relationship between the self-reported learning style perceptions and flow experiences was identified.
- (x) A significant relationship between the self-reported learning style perceptions and the learning attainment was identified.
- (xi) Significant differences between college students and undergraduates were revealed, in particular differences in the:
  - a) Learning attainment.
  - b) Self-reported learning style perceptions.
  - c) Time of day the test was taken.

### **Conclusion about the research questions**

The main aim of this research was to identify if the inclusion of music and/or animation in an e-learning interface could influence a learner's emotional state, in particular their ability to enter a state of flow, and also their learning attainment. The results from the music and animation study showed that the inclusion of this style of music and animation had no significant effect upon learning attainment, but did have a significant effect upon a learner's ability to enter a state of flow.

The delivery methodology used in this study was a PowerPoint-style presentation. This method of delivering e-learning only represents a small subset of the delivery methods available, and other methods include podcasts and 3D virtual worlds such as Second



Life. However, PowerPoint-style presentations are still a popular method of delivery as they require a relatively low level of computer skill to produce. Without further work it is unclear if the results from this study can be generalised to other methods of delivery or not.

It was found that the inclusion of both music and animation, or animation alone, had a detrimental effect upon the participants' ability to enter a state of flow when compared with the situation without any music or animation. The inclusion of the music alone did not produce any significant differences.

Hence it is clear that the selection of music and animations for use in e-learning environments is critical, and while the use of music and or animation may have the potential to enhance the emotional state of a learner, it definitely has the ability to negatively impact upon a learner's emotions.

Hypotheses about the effects of the inclusion of music and animations upon the different constructs of flow were formulated and the results from this study showed that, as hypothesised, the flow constructs of clear goals, feedback and skill/challenge levels are unaffected by the inclusion of this style of music and/or animation in this type of learning situation. Also as hypothesised the sense of control was reduced with the inclusion of additional elements. It was also hypothesised that the constructs of concentration, focus, loss of self-consciousness and transformation of time would be positively affected by the inclusion of music and/or animation. However, the constructs of focus and loss of self-consciousness were unaffected by the inclusion of music and/or animation. Whilst concentration and transformation of time were unaffected by the inclusion of music and animation individually, when the music and animation were combined a negative affect was seen.

It was also found that the self-reported learning style perceptions were related to the participants' abilities to enter a state of flow and also upon their learning attainment. These results disproved hypothesis 3 in which it was expected that the perceived learning styles would have no effect upon the state of flow or learning attainment. In particular, those who reported having a perceived preference for intrapersonal and logical/mathematical produced higher results for the learning attainment than those who did not report these perceived preferences.

### **Conclusions about the additional findings**

The literature review of flow in online environments carried out in chapter 5 showed that while people can and do experience flow episodes when engaging in online activities, the measurements of these flow experiences can vary widely between the different studies. Therefore it is difficult to obtain clear comparisons between them. What is needed is a clearer framework not only for describing flow but also to provide a more standardised methodology for measuring flow. This study has gone some way towards this by identifying the flow constructs and measurement methods most commonly used. This study also created a methodology for providing further validation of the eight-channel model of flow, which it is hoped will be utilised by other researchers investigating flow experiences.

Distinct differences between the college and undergraduate student groups were identified. Several key differences were noted:

1. Learning attainment.

2. Self-reported learning style perceptions.
3. Time of day the test was taken.

The undergraduate group achieved higher results for learning attainment than the college group, which was not expected given the simplicity of the learning task set.

It was suggested in chapter 9 that learning attainment might have been affected by the perceived learning styles, given that there was also a difference between the two groups and the perceived learning styles they reported.

Lastly there was a significant difference identified in the time of the day that the two groups were taking the test. Being an online test it followed the ethos that e-learning is available 24 hours a day, seven days a week. The time of day the test was taken was recorded and it was found that there were significant numbers of college students taking the test at 11am and again at 2 pm, while undergraduate students were evenly spread throughout the day. The reasons for this are unclear, but it has been suggested that this could be due to institutional constraints. Further research would be required to gain a deeper understanding of the differences between the student groups that were identified during this study.

Future researchers collecting data from these two student groups, or other student groups, might also consider recording the location of study to enable further comparisons of these groups to be carried out.

Although the two pieces of music selected clearly produced the most positive emotions amongst the participants during the music selection experiment, when the music was then embedded into the e-learning task for the music and animation study, the results were not so positive. One could argue that it may have been more appropriate for the presentation designer to select the music rather than have the music selected by initially

testing for the emotions it evoked, because the designer could imagine the completed presentation and have an understanding of the overall effect they wanted it to express.

## **10.2 Future work**

This study recorded data about the emotions and state of flow, learning attainment, perceived learning styles and area of study of participants. While some of these elements may seem to be unrelated, such as the area of study and perceived learning style preferences, analysis has shown that there were relationships between several of these elements which were not expected. In this chapter some of these relationships are highlighted and suggestions for further research to better understand these relationships are described, along with general areas of future research.

### **Music and animation styles**

This study has clearly shown that the use of music and animation does have an effect upon the learner's emotions and state of flow. While the music and animations used in this study had a detrimental effect upon the learner, it is possible that a different style of music and/or animations could enhance a learner's emotional state.

Whilst this study has gone some way towards a better understanding of the use of music within e-learning, the full potential of music within computer-mediated environments has not yet been realised in the way it has within other areas of society, such as marketing, film and therapy (see chapter 2). Thus there would be value in carrying out further research into the potential uses of music within interface design, not only in e-learning environments but also within other computer-mediated environments. Further

research into the use of music within e-learning tasks is all the more compelling when one considers the findings from the music test described in chapter 4 that identified 92.9% of people listened to music at some point while working within an online environment. It was also evident that the preferred styles of music to listen to while working were rock and classical, while jazz music was not listened to very often while working, although it was liked by people. However, there is little evidence that rock or classical music are more conducive to an optimal learning state than any other type of music. Future studies could examine different styles of music and/or animation and aim to identify whether particular styles of music are more conducive to a state of learning, as well as possibly establishing an optimal period for playing music during a learning task. In this study the music was only played for short periods interspersed throughout a PowerPoint-style presentation. Again, there might be an optimal time-period for playing the music, particularly as it was found in the final test (see chapter 8) that a short 30-second burst of music might not have been long enough to have had an impact upon a learner's emotions. The most appropriate music to use and the time it is played for is likely to be dependent upon the learner's personal preferences, and possibly other attributes such as age, and these would need to be taken into account. It might be that the wide range of music and animation styles available and a learner's personal variations prove to be so extensive that a definitive model would be impossible to achieve. However, if future research in this area could generate a better understanding and provide guidelines for educational developers this would be of great value.

### **Learning attainment**

Although the learning attainment in this study was unaffected by the inclusion of music and/or animation, other research has shown that the flow experiences of the learner can

have an impact upon the learning attainment (Ho & Kuo, 2009; Choi et al. 2007). It was also evident in this study that the participants who reported experiencing positive emotions viewed the presentation for longer than those who reported negative emotions. Further research into the effects of a learner's emotional state are obviously required since the emotions of participants in this study was clearly affected by the inclusion of music and animation. Future research along similar lines to this study could focus more specifically upon learning attainment and the impact of music and animation by using deeper analysis of the learning taking place. This would be particularly interesting since this study identified that the number of revisits to previous slides and the total amount of time spent viewing affected learning attainment. Further research could aim to identify if this is due to a reflective learning process or for some other reason.

### **Perceived learning styles**

This research identified a link between learning attainment and particular perceived learning styles, and it was found that those who self-reported having a preference for being intrapersonal or logical/mathematical had a higher level of learning attainment than those who did not report these categories. Of course it would be incorrect to assume that these perceived learning style preferences would produce a higher learning attainment in every learning situation, but further research might identify particular learning situations that are best suited for people with different perceptions of their learning style preferences. Future research could also investigate whether learners who perceive themselves as intrapersonal are particularly well suited to the individual learning situations so often imposed by e-learning environments. It was interesting that the self-reported learning style preference of logical/mathematical should have produced a higher level of learning attainment, since the learning content was not logic

or mathematics based. Thus, future studies could examine if perceived learning styles affect learning attainment, not because of the actual content or method of content delivery, but more by the environment in which the learning task is set, i.e., e-learning as opposed to classroom-based. Additionally this research revealed that the reported level of skill required and challenge posed by the learning task was related to the self-reported learning styles perceptions. Again this might have been as a result of the environment and may also have had an effect upon learning attainment. Further research probing deeper into the effects of perceived learning styles within different e-learning environments using different methods of delivery and content could serve to broaden and clarify the current understanding of the effects of perceived learning style preferences.

## **Flow**

Several unanswered questions about flow arose as a result of this study and these require further research in order to ascertain the answers. The areas in question are listed below:

1. The self-reported learning style perceptions and emotions of the learners had an impact upon their level of flow. However, it is unknown if these perceived learning styles and emotions would affect a person's level of flow in the same manner during a different task or in a different environment. Further research would be necessary to reveal if the perceived learning styles and emotions of learners always have the same impact upon the level of flow, independent of the task or environment.

2. Whilst a clear difference was seen in the level of flow between the four learning situations in the music and animation study, the same difference was not seen in the final test described in chapter 8. This was assumed to be as a result of the shortened timescale of the data collection points. This raised the question of how much time was needed to alter a person's level of flow where the challenge level and skill requirements remained relatively static. Equally one could question how much the level of challenge needed to be altered before the level of flow would be affected. Of course there may not be a conclusive answer to these questions, but further investigation of the temporal stability of flow could enhance current understanding.
3. It may have been due to the experimental design or the design of the presentation used in the music and animation study that the flow construct of control was so strongly affected by the inclusion of music and animation, while other constructs were less affected. Some of the constructs, such as time distortion and concentration were also affected by the emotions whereas the construct of feedback was affected very little by the emotions. Again one could presume that this was due to the test design and with different tasks the constructs might be affected differently. For example, researchers such as Partala and Surakka (2004) and Klein et al. (2002) showed how feedback could have a strong effect upon the emotional state of a participant. Further research into how different tasks impact upon the different constructs of flow would be of benefit as it could inform designers, enabling them to have a better understanding of a user's experience.



Validation of the eight-channel model of flow was sought in this study by recording the participant's emotions along with their perceived level of challenge and skill for the task. This allowed the emotions to be mapped to the level of challenge and skill. Although a direct mapping was not achieved in this study, it is believed that this method of validation may prove to be useful in further studies which explore flow experiences. It would be anticipated that where tasks pose a higher level of challenge, or require a higher level of skill than the one set in this study, stronger support for the eight channel model of flow might be seen by means of a closer mapping between the emotions and the level of skill and challenge.

### **Differences in student groups**

Analysis of the results from this study revealed some intriguing differences between the undergraduate and college student groups. It appears that most other studies whose participants include undergraduates and college students either target one group or the other. Additionally, those who target both groups may not record which group the participants are from and thus the data from both groups are combined and analysed as one.

Differences between the groups were seen in learning attainment. Since the learning task set was not a particularly challenging one it was not clear why the undergraduate students' learning attainment was significantly higher than the college students. The self-reported learning styles perceptions also differed between the groups, as did the time of day the tests were taken. Possible reasons for these findings were discussed in chapter 9, but further research into this area could clarify differences found between the groups. It was suggested earlier that the differences in the perceived learning style

preferences might have caused the learning attainment to be higher in the undergraduate group, as this group selected the preference of intrapersonal and logical/mathematical more often than the college students. As discussed earlier, these particular perceived learning styles appeared to have an impact upon the learning attainment in this particular task. Thus further research may firstly seek to confirm the findings of the differences in perceived learning style preferences between the groups, and elaborate further to investigate possible differences in the actual learning styles between the groups. Secondly, research is needed to gain a deeper understanding of why the undergraduate group should have achieved higher levels of learning attainment than the college students and to identify if there is any link between this and the perceived learning style preferences. Finally, research into the reasons for differing times of day that the test was taken could be useful as it was unclear if this was due to chronobiology (personal preferences for the time of day for particular tasks), or if it was due to a difference in the institutional structure of timetables, and if so what repercussions such structures could have upon other areas of a student's learning processes.

Of all the potential areas of future research identified here it is clear that there would be value in furthering the understanding and use of music and animations within e-learning tasks to enable guidelines for best-practice to be created. A deeper understanding of flow and further validation of the eight-channel model of flow would also contribute to the knowledge base. However, perhaps the most unexpected area identified for future investigation was the differences between the undergraduate and college student groups. Further research in this area has the potential to impact strongly on our understanding of student profiles, including their perceived learning styles and actual learning styles, and upon how different educational institutions may adapt in order to accommodate and support students with different profiles. Perhaps even the advice given to prospective

students who are yet to decide upon their location of future study may be affected by a new and deeper understanding of students and educational institutions. Work has already begun on a research proposal to enable the research in this area to continue.

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# **Appendix A**

## **Pilot study question set**

### **The general background questions**

These were the questions asked in the pilot study.

What age group are you in?

*Up to 20, 21-30, 31-40, 41-50, 51-60, 61-70, 71 and over*

What gender are you?

*Male , Female*

Which best describes your ethnic culture?

*European, African, West Indian, Caribbean, Asian, Other*

What type of music do you like? (check all that apply)

*Classical, Jazz/Blues, Heavy metal/Punk rock, Rock/Pop, New age, Other*

How often do you listen to music while you are working or studying?

*Never, Occasionally, Often, Most of the time*

***\*Participants were then asked: if you never listen to music while working or studying please skip the following 3 questions.***

What type of music do you listen to while working or studying? ( check all that apply)

*Classical, Jazz/Blues, Heavy metal/Punk rock, Rock/Pop, New age, Other*

What are your reasons for listening to music whilst working or studying? (check all that apply)

*Block out noise, Enjoy the music, Helps me concentrate, Other*

Where do you normally listen to music whilst working or studying?

*Public place (e.g. the computer labs), Home environment, Equally in public place and home environment*

**Second question set**

Participants were first asked “When answering the next set of questions please think about the whole presentation and how you felt at times during the presentation.”

Next to each question there was an area to write any comments the participant may have had.

**1) I liked the way the Power Point slides were presented**

*strongly agree*

*agree*

*neither agree or disagree*

*disagree*

*strongly disagree*

**2) The presentation made me feel :-**

*alert all of the time*

*alert some of the time*

*indifferent*

*not alert*

*not alert at any time*

**3) The way in which the content was presented:-**

*helped me to concentrate*

*helped me to concentrate at times*

*did not alter my concentration*

*made it harder for me to concentrate*

*made it very hard for me to concentrate*

**4) Watching the presentation made me feel:-**

*happy most of the time*

*happy at times*

*indifferent*

*sad at times*

*sad all the time*

**5) The music being played was the sort of music I would:-**

*normally choose to listen to*

*occasionally choose to listen to*

*not normally choose to listen to*

*rarely choose to listen to*

*never choose to listen to*

**6) While watching the presentation I experienced:-**

*a sense of satisfaction and excitement*

*a sense of satisfaction or excitement*

*no sense of satisfaction or excitement*

*a sense of dissatisfaction and boredom*

**7) I felt the music:-**

*captured my attention and enhanced my understanding of the content*  
*did not enhance my understanding of the content but did capture my*  
*attention*

*distracted my attention but did help my understanding of the content*  
*distracted my attention and did not help my understanding of the content*

**8) Watching the presentation made me feel**

*happy*  
*a little happy*  
*indifferent*  
*a little sad*  
*sad*

**9) I liked most of the music being played**

*strongly agree*  
*agree*  
*indifferent*  
*disagree*  
*strongly disagree*

**10) I would like to have more presentations delivered in this way**

*strongly agree*  
*agree*  
*indifferent*  
*disagree*  
*strongly disagree*

**11) Please say what you liked the most about the presentation**

**12) Please say what you would change about the presentation**

Participants were then asked for any other comments.

# **Appendix B**

## **Ethical approval - information sheets and consent form**

## **Information about ‘The interface issues of e-learning’**

The project began in October 2005 and will run until September 2008.

The aim of this project is to develop ways of improving the interfaces and interaction of e-learning applications. It is well known that there are inherent problems with e-learning such as a lack of motivation in the student, lack of social interaction and often problems with knowing how to use the technology. Whilst there have been many improvements in e-learning environments such as the introduction of web conferencing, students are in some cases still experiencing problems within the e-learning environments. This project will examine some of these problems and try to address them by improving the interface design.

The student's thoughts about the e-learning environments are essential for this projects development.

Participants will be asked to complete questionnaires in order to gain an insight into their thoughts. A selection of interfaces will be developed according to the feedback from the initial questionnaires and participants will then be asked to evaluate them by follow-up questionnaire and/or interviews and/or focus group.

Participants will be asked to sign a form saying that they are willing to participate in the study. The consent form will explain what will be asked and what will happen to any information which is collected. The participants will be given a copy of this form to keep.

If you would like to know more about this research and/or you have questions that cannot be answered by the researcher, please feel free to contact the principal investigator, Sue Grice, Division of Applied Computing, University of Dundee, Dundee DD1 4HN. She can be contacted by phone at (01382) 386541 or by email at [sgrice@computing.dundee.ac.uk](mailto:sgrice@computing.dundee.ac.uk).

## Informed Consent Form – Participants

Dear Participant

Thank you for your interest in the Interface issues of e-learning Study. This page describes what you will be asked to do for the study. Please read through it and then sign at the bottom to say that you understand and accept the conditions of this study. If you have questions, please feel free to ask the researcher.

The researcher will begin by asking you for some general information about yourself. You will then be asked to fill in a questionnaire and then view some different interface designs. You will then be asked to talk about what you think or to fill in another questionnaire. Questions about how you felt about the experience of using the system will also be asked.

Please note that the study is focused on the evaluation of the new interfaces. Participants are not being tested – it is the system that is being tested. There are therefore no right or wrong answers. Your participation in this study is voluntary and you can leave the study at any time without penalty or giving reasons. No undue risk arises from the participation in this study.

All the information which you give us and any videotapes (that is all data) will be stored safely and kept separate from information about your identity. Access to your data is minimised to the people involved in this research. If information about you is used for publications or presentation, we will ensure that no reference to your identity is made. If a video-clip is used for presentation, your name will be changed. With reference to the use of video data for presentations, please tick one of the following boxes:

☐ I **agree** that my likeness (e.g. on videotape) can be used for presentations.

☐ I **do not agree** that my likeness (e.g. on videotape) can be used for presentations.

The researchers are very grateful for your help. It is important that you understand that this is a research project and that you will not be able to have a system like this now. We hope that one day you may be able to buy a system like the one we are developing. However, even if a system like this does not work, the help you have given us will give us ideas about how interfaces for e-learning applications may be improved in the future.

Please date and sign this page below to indicate that you understand and accept the conditions of this study. Thank you.

*Name of Participant:* \_\_\_\_\_

*Signature:* \_\_\_\_\_

*Date:* \_\_\_\_/\_\_\_\_/200\_\_



## Online consent screen shots

### What is it all about?

- You are about to watch a presentation about learning styles and study methods.
- As part of a study into interface design and e-learning you will be asked some questions before and after the presentation.
- All the results recorded are anonymous.

 Previous

Next 

### Questions

You will be asked some questions before and after the presentation.

The questions relate to how you felt during the presentation and what you know about learning styles.

Most of the questions require you to select one or more answers for each question

☒ selected

☐ unselected

These buttons allow **only one** answer per question

☒ selected


☐ unselected

These buttons allow **several** answers per question

For some questions there is the option ☒ I really don't know

**Only** use this option if you **REALLY** have no idea

 Previous

Next 

### Informed Consent Form

Please note that the study is focused on the evaluation of the presentation. Participants are not being tested – it is the presentation that is being evaluated.

Your participation in this study is voluntary and you can leave the study at any time without penalty or giving reasons. No undue risk arises from the participation in this study.

All the information which you give us will be kept separate from information about your identity. Access to your data is minimised to the people involved in this research. If information about you is used for publications or presentation, we will ensure that no reference to your identity is made.

Please click the appropriate box below to indicate that you understand and accept the conditions of this study.

**Accept**

**Decline**

 **Previous**

# **Appendix C**

## **ANew mappings**

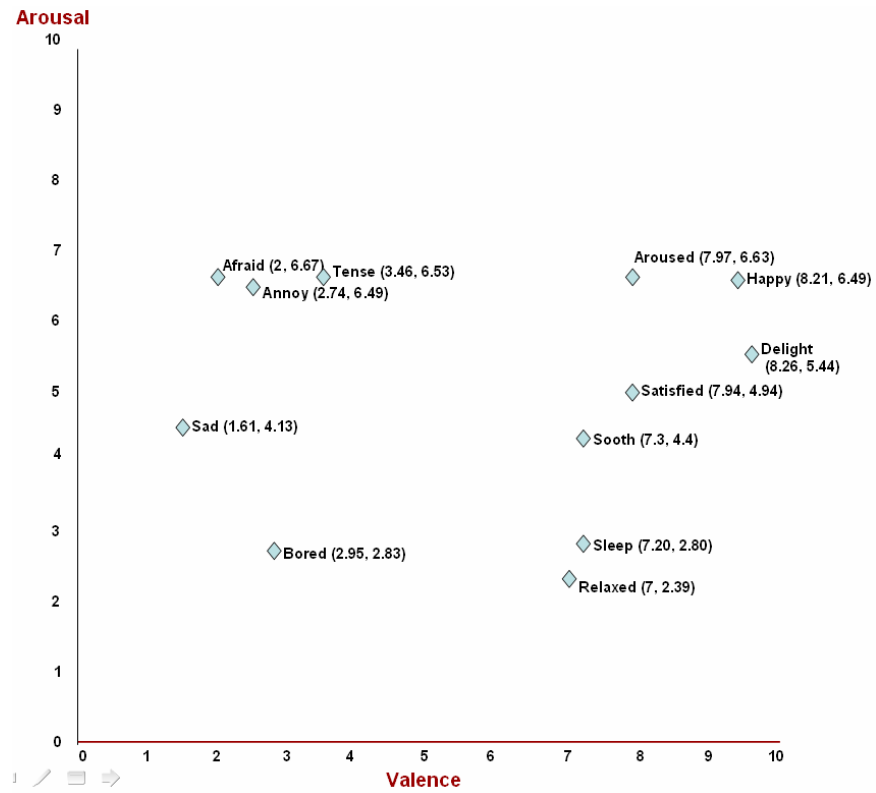


Figure showing the positions of the ANEW word ratings.

# **Appendix D**

## **Experiment 1 – general data questions**

Below are the general questions asked in the music test, along with the answers available to select from. This was presented as an online questionnaire.

- 1) What age group are you in?  
*Up to 20, 21-30, 31-40, 41-50, 51-60, 61-70, 71 and over*
- 2) What gender are you?  
*Male , Female*
- 3) Which best describes your ethnic culture?  
*European, African, West Indian, Caribbean, Asian, Other*
- 4) What type of music do you like? (check all that apply)  
*Classical, Jazz/Blues, Heavy metal/Punk rock, Rock/Pop, New age, Other*
- 5) How often do you listen to music while you are working of studying?  
*Never, Occasionally, Often, Most of the time*
- 6) What type of music do you listen to while working or studying? ( check all that apply)  
*Classical, Jazz/Blues, Heavy metal/Punk rock, Rock/Pop, New age, Other*
- 7) What are your reasons for listening to music whilst working or studying? (check all that apply)  
*Block out noise, Enjoy the music, Helps me concentrate, Other*
- 8) Where do you normally listen to music whilst working or studying?  
*Public place (e.g. the computer labs), Home environment, Equally in public place and home environment*

# **Appendix E**

## **Results: Experiment 1 – emotional variation**

There was no significant difference in the pleasantness or arousal levels over the 30-second time periods that the music was played for when analysed with an ANOVA test.

The arousal and pleasantness levels were recorded every 2 seconds. The table below gives the results for each piece of music.

Music name	Result for pleasantness level	Result for arousal level
04-8 Symph 1st-Philharmonia Baroque_60.mp3	$F(14, 90) = .550, p=.896$	$F(14, 90) = 1.130, p = .344$
Big Chill_60.mp3	$F(14, 120) = 1.641, p=.0.78$	$F(14, 120) = 1.695, p=.065$
Speed Freak_60.mp3	$F(14, 105) = 1.284, p=.230$	$F(14, 120) = .175, p=1.00$
Touch Me_60.mp3	$F(14, 90) = 1.029, p=.432$	$F(14, 90) = .649, p=.817$



# **Appendix F**

## **Details of the music used in the experiments**

**Table 1: Music used in Experiment one – emotions evoked and expressed**

Music title	Source	Music number
Uncle Bavaria	AudioLicence	Music#1
Lost Horizons	AudioLicence	Music#2
Mean Streets	AudioLicence	Music#3
Lava Love	AudioLicence	Music#4
Tense1	Magnatune.	Music#5
Sad1	Royaltyfreemusic	Music#6
Bootz	AudioLicence	Music#7
Relax1	Magnatune	Music#8

**Table 2: Music used in Experiment one – emotional variation**

Music title	Source
Big Chill	AudioLicence
Speed Freak	AudioLicence
Touch Me	AudioLicence
04-8 Symph 1st-Philharmonia	Magnatune

**Table 3: Music used in Experiment two – emotions evoked**

Music title	Source	tempo bpm	key	Music number
Bootz	AudioLicence	112	Dm	Music1
Uncle Bavaria	AudioLicence	118	Bb/A#	Music2
Lobster Tureen	AudioLicence	100	E	Music3
Lo-Fi Funk	AudioLicence	120	Cm	Music4
Gumshoe	Audiolicence	149	Am	Music5
I Spy 2	AudioLicence	100	Cm	Music6
Bewitched	AudioLicence	112	Fm	Music7
Monkey Tennis 2	AudioLicence	112	F	Music8
Mean Streets	AudioLicence	90	Am	Music9
Lava Love	AudioLicence	76	B	Music10
Lost Horizons	AudioLicence	n/a	Gm	Music11

# **Appendix G**

**Experience Sampling Method  
questions and the skill/challenge  
graph**

Below are the Experience Sampling Method (ESM) questions that were asked in the main test. The questions were presented to the participants in one of five random-order patterns.


The questions were presented along with a 5 point Likert scale – strongly agree, agree, neither agree or disagree, disagree, strongly disagree.

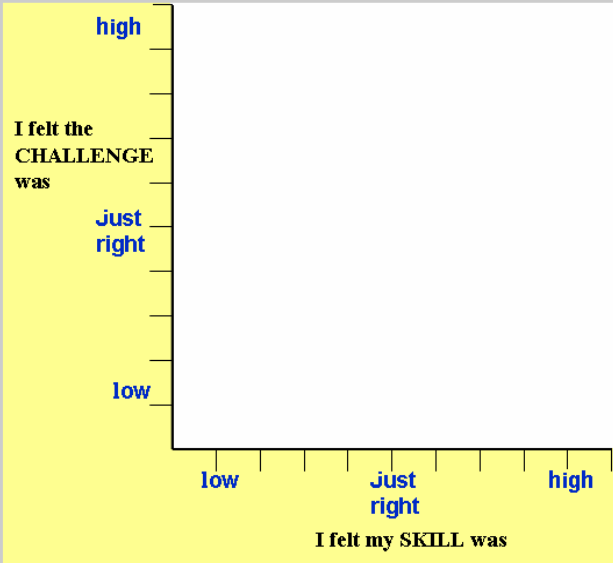
1. I knew clearly what I was supposed to do.
2. I was concentrating fully on the activity.
3. I always felt in control.
4. During the presentation, I forgot about my immediate surroundings.
5. I was so focused that I completely lost track of time.
6. I was absorbed intensely in the activity.
7. I got direct clues as to how well I was doing.
8. I thought about other things.
9. I felt that during the presentation, I was more in the “computer world” than the “real world” around me.
10. I was aware of distractions.
11. I knew where I was and knew where to go next and what to do next.
12. I felt frustrated.
13. Time went faster than I thought and I did not even sense it.
14. I knew how well I was proceeding.

Figure 1 shows a screen shot of how the questions were presented to the participant in the online environment.

Please answer the following questions with regard to the presentation you have just watched.	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree		
I knew clearly what I was supposed to do	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I was concentrating fully on the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I always felt in control	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
During the presentation, I forgot about my immediate surroundings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I was so focused that I completely lost track of time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I was absorbed intensely by the activity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I got direct clues as to how well I was doing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I thought about other things	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I felt that during the presentation, I was more in the "computer world" than the "real world" around me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I was aware of distractions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I knew where I was and knew where to go next and what to do next	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I felt frustrated	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Time went faster than I thought and I did not even sense it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
I knew how well I was proceeding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
Which age group are you in?	<input type="radio"/> Up to 16	<input type="radio"/> 16-20	<input type="radio"/> 21-30	<input type="radio"/> 31-40	<input type="radio"/> 41-50	<input type="radio"/> 51-60	<input type="radio"/> 61+
Thank you, now please click the NEXT button <input type="button" value="NEXT"/>							

Figure 1: Screen shot of the ESM questions

Think about how you felt during the presentation then drag and drop this ball  into the appropriate place on the graph below. [Show me an example](#)



The graph is a square with a yellow background. The vertical axis is labeled 'I felt the CHALLENGE was' with tick marks for 'low', 'Just right', and 'high'. The horizontal axis is labeled 'I felt my SKILL was' with tick marks for 'low', 'Just right', and 'high'.

Now select the emotion which best describes how you felt during the presentation

Anxious	<input type="radio"/>
Arousal	<input type="radio"/>
Enjoyment	<input type="radio"/>
Control	<input type="radio"/>
Boredom	<input type="radio"/>
Relaxation	<input type="radio"/>
Apathy	<input type="radio"/>
Worry	<input type="radio"/>

**Next scroll the page down and answer the questions below**

**Figure 2: Screen shot of the skill / challenge graph and emotional selection**

Figure 2 shows the skill/challenge graph with an orange ball for the participants to drag and drop onto the graph where they felt appropriate. There was also a list of emotions to select from on the right-hand side of the screen.

# **Appendix H**

## **The Pre- and Post-test questions**

The following questions were asked in the pre- and post-tests. They were ordered in five different ways. Each participant was presented with one of the five ordering patterns. For each ordering pattern the pre- and post-tests were the ordered the same.

**1. Which one of these learning styles do you think would be best for work at school, college or university?**

- Logical / Mathematical
- Verbal / Linguistic
- Visual / Spatial
- Judging / Perception
- None of the above
- All or any of the above
- I really don't know

**2. Gardner's 'Multiple intelligences' refers to -**

- academic intelligence
- different styles of learning
- very intelligent people
- multi-talented people
- I really don't know

**3. A person is likely to -**

- use only their preferred learning style
- use many different learning styles depending upon the task
- use mainly their preferred learning style but may also use other styles
- not use any style
- I really don't know

**4. Which of theses are both brainstorming techniques?**

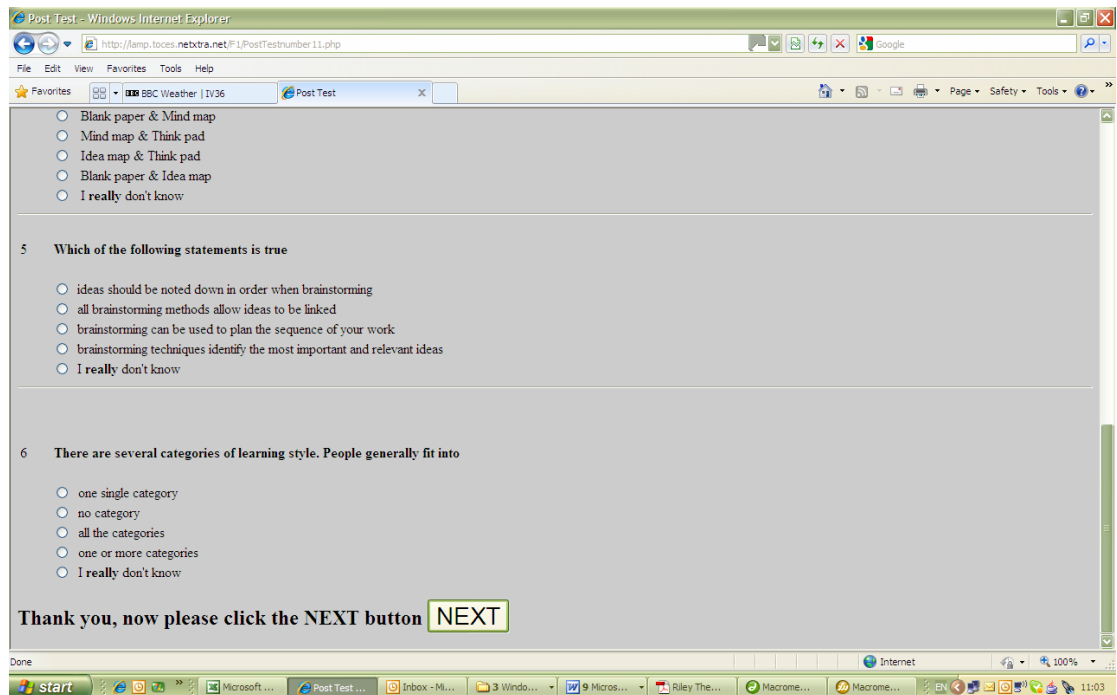
- Blank paper & Mind map
- Mind map & Think pad
- Idea map & Think pad
- Blank paper & Idea map
- I really don't know

**5. Which of the following statements is true?**

- ideas should be noted down in order when brainstorming
- all brainstorming methods allow ideas to be linked
- brainstorming can be used to plan the sequence of your work
- brainstorming techniques identify the most important and relevant ideas
- I really don't know

- 6. There are several categories of learning style. People generally fit into-**
- one single category
  - no category
  - all the categories
  - one or more categories
  - I really don't know

Figure 1 shows a screen shot of how the questions were presented in the online format.

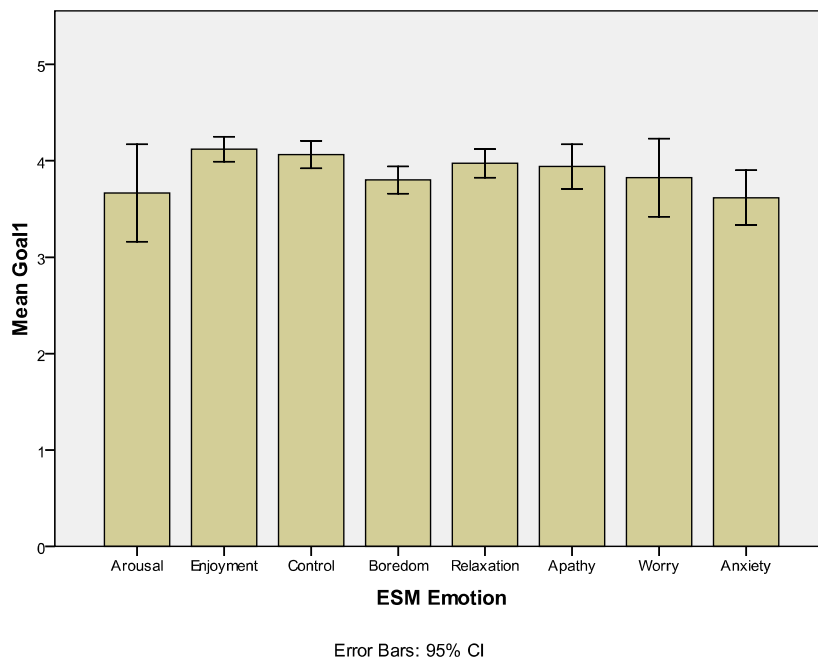


**Figure 1: A screen shot of the pre- and post-test questions**

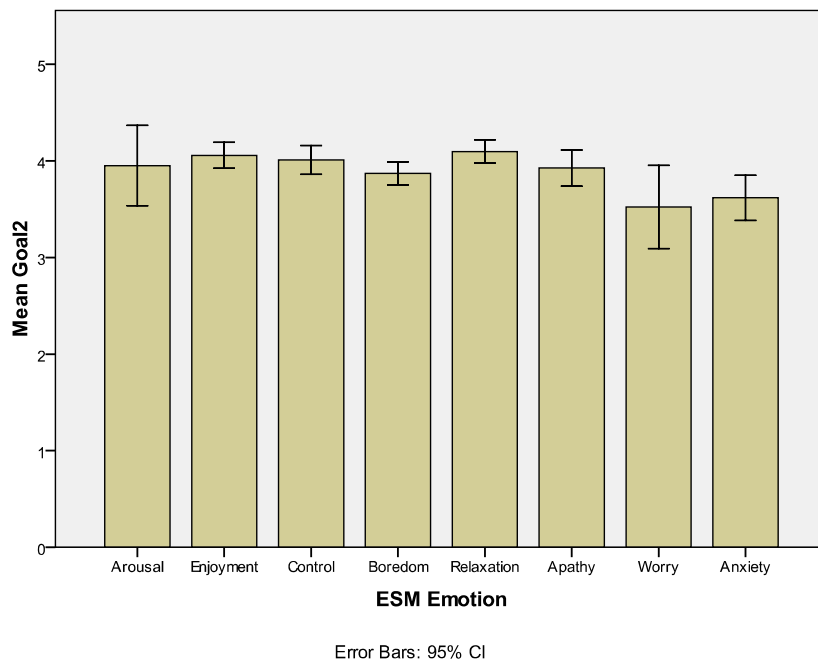


# **Appendix I**

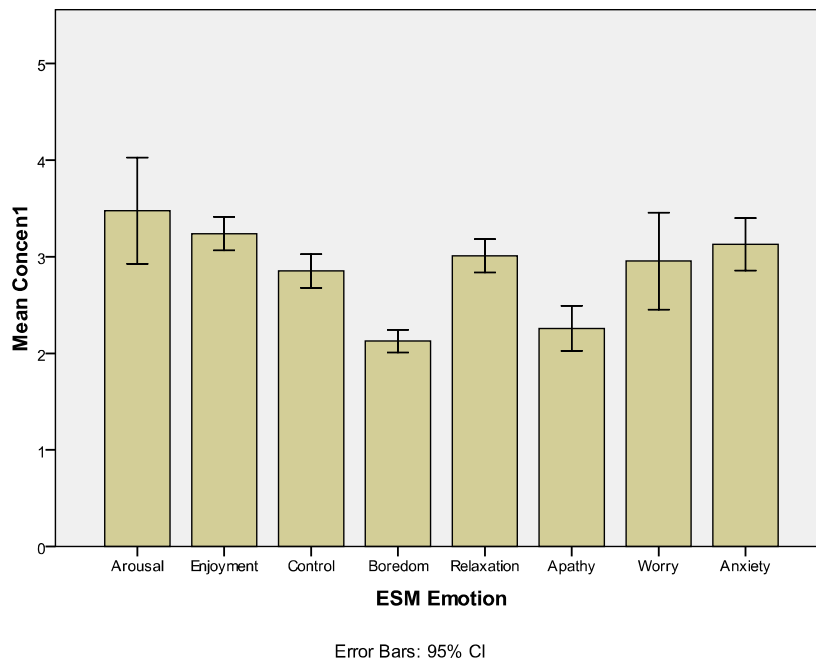
**Figures for each of the ESM questions  
and the emotions**



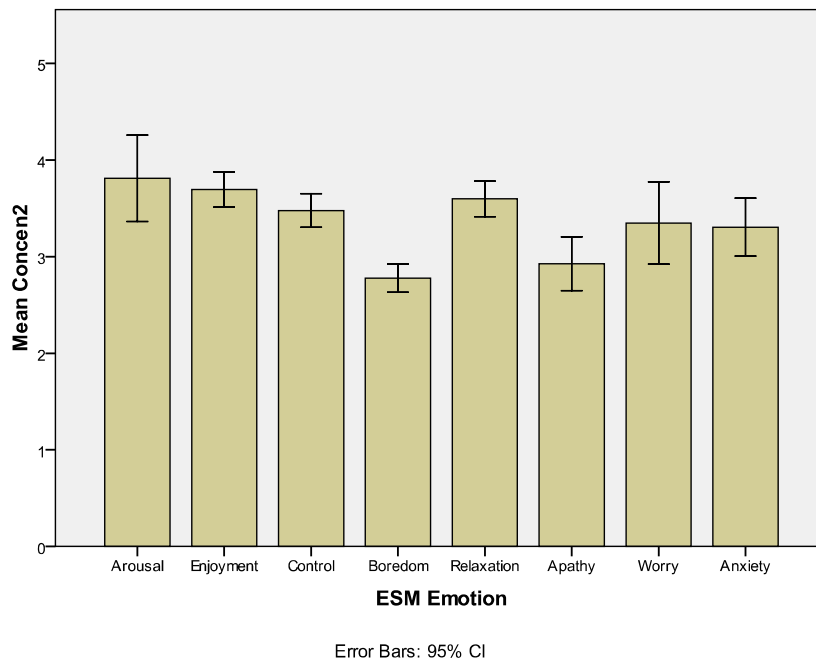
**Figure 1: Goal1 – I knew clearly what I was supposed to do.**



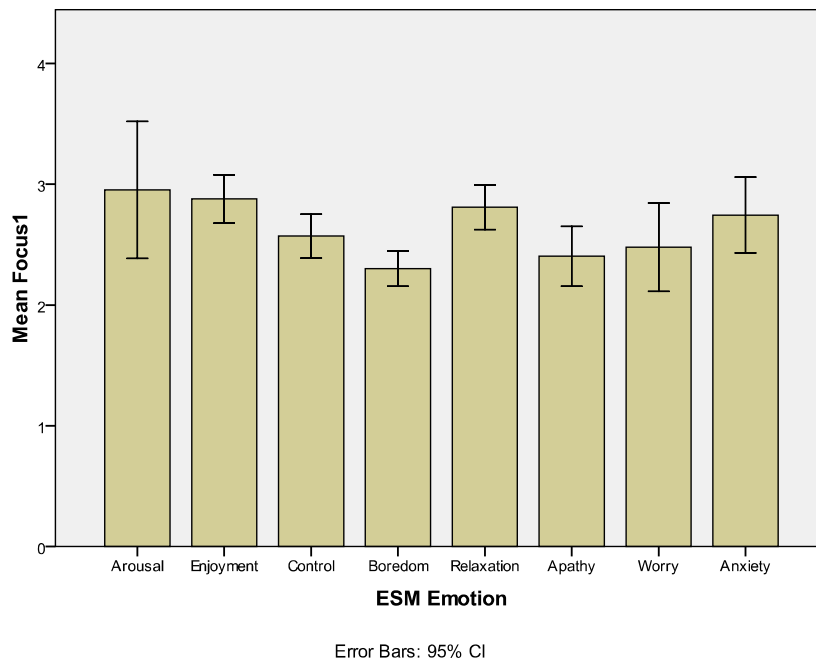
**Figure 2: Goal2 – I knew where I was and knew where to go next and what to do next.**



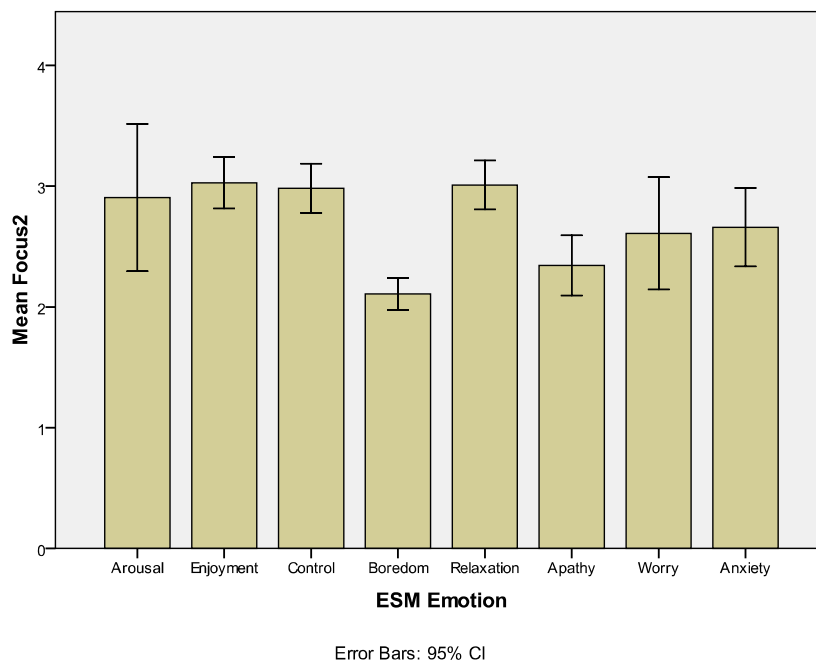
**Figure 3: Concen1 – I was absorbed intensely in the activity.**



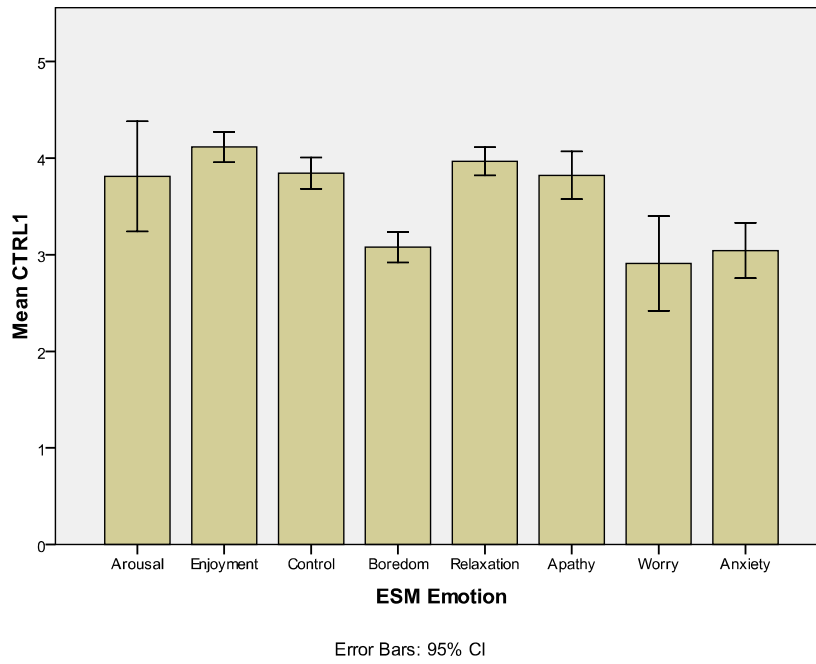
**Figure 4: Concen2 – I was concentrating fully on the activity.**



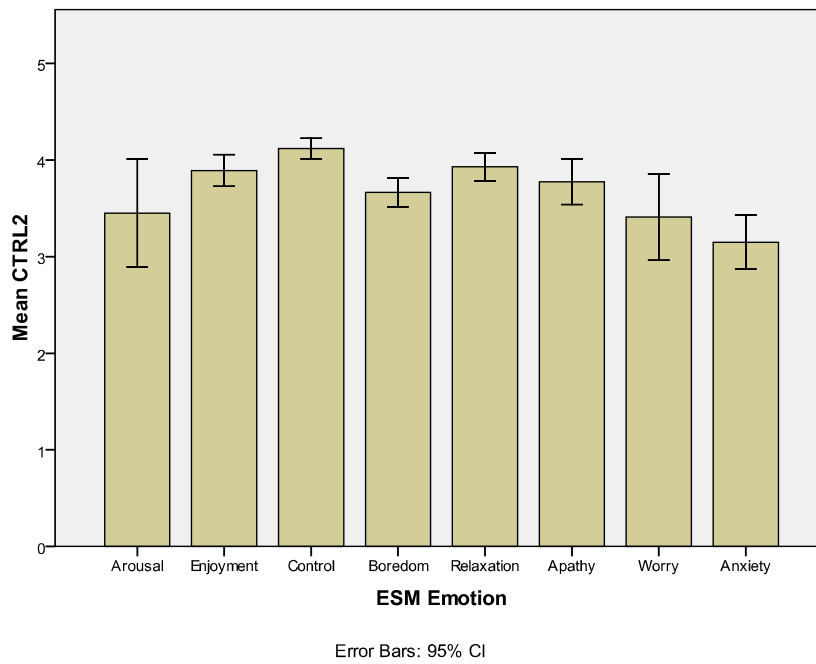
**Figure 5: Focus1 – I was aware of distractions.**



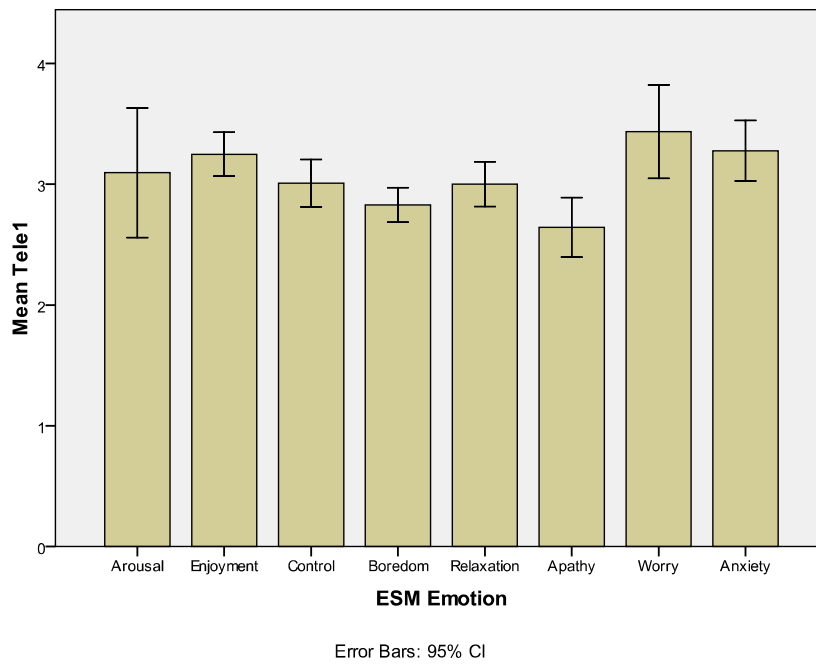
**Figure 6: Focus2 – I thought about other things.**



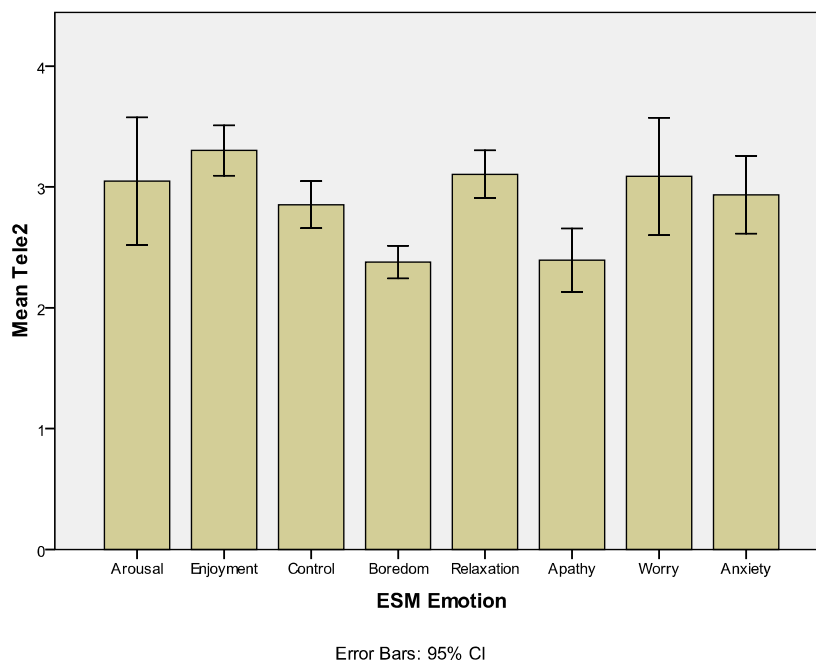
**Figure 7: CTRL1 – I felt frustrated.**



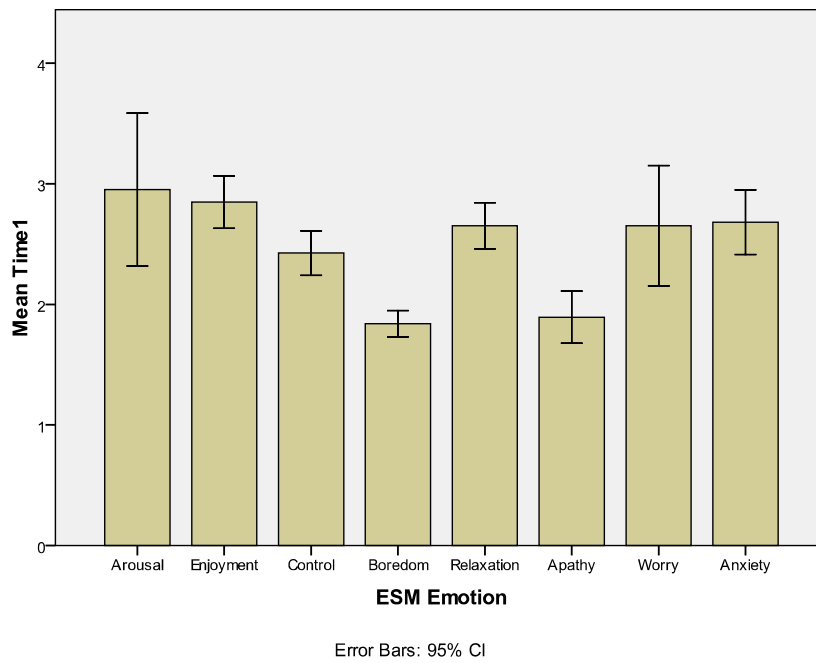
**Figure 8: CTRL2 – I always felt in control.**



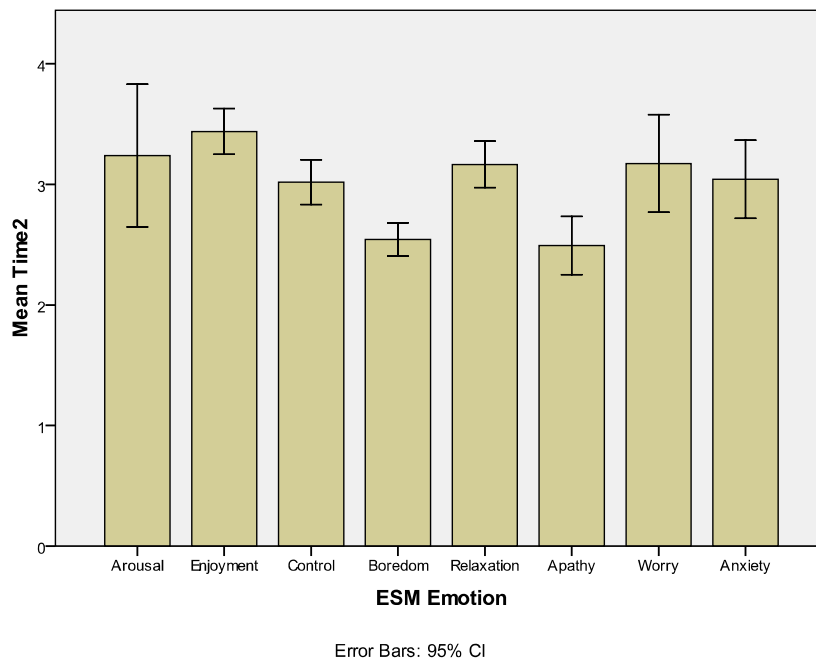
**Figure 9: Tele1 – I felt that during the presentation I was more in the “computer world” than the “real world” around me.**



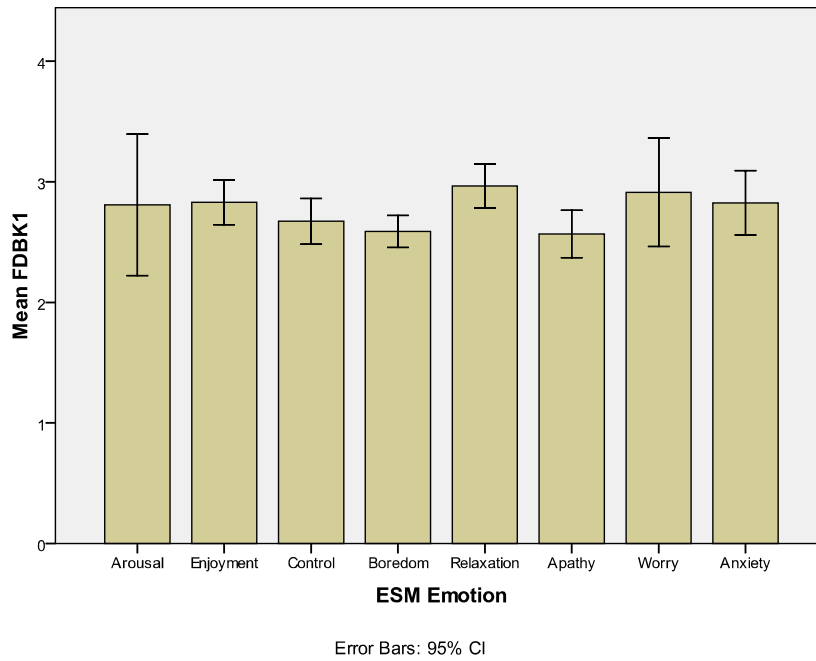
**Figure 10: Tele2 – During the presentation I forgot about my immediate surroundings.**



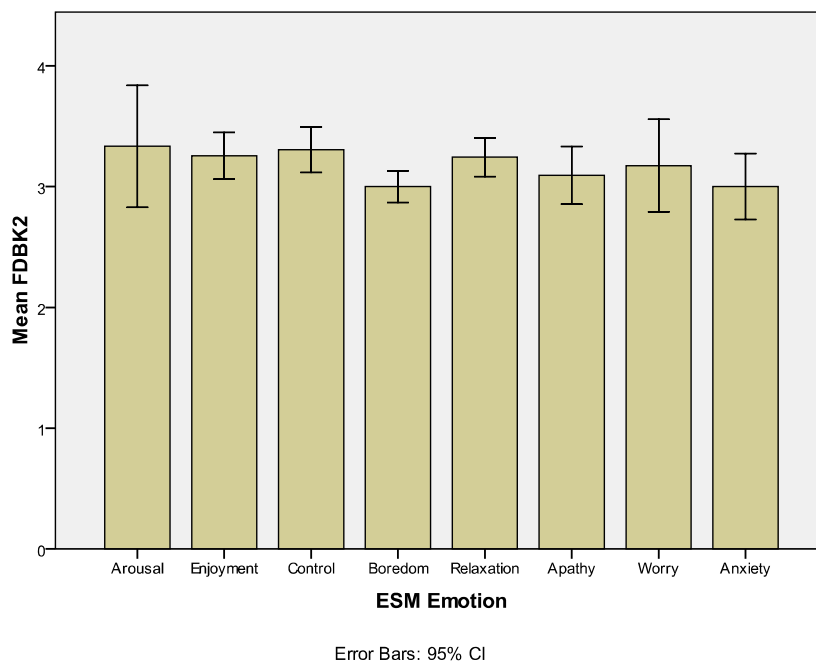
**Figure 11: Time1 – I was so focused that I completely lost track of time.**



**Figure 12: Time2 – Time went faster than I thought and I did not even sense it.**



**Figure 13: FDBK1 – I got direct clues (feedback) as to how well I was doing.**



**Figure 14: FDBK2 – I knew how well I was proceeding.**